THE CINEMA TO-DAY

A FRAME OF TECHNICOLOR SUBTRACTIVE COLOUR FILM

(See page 106)

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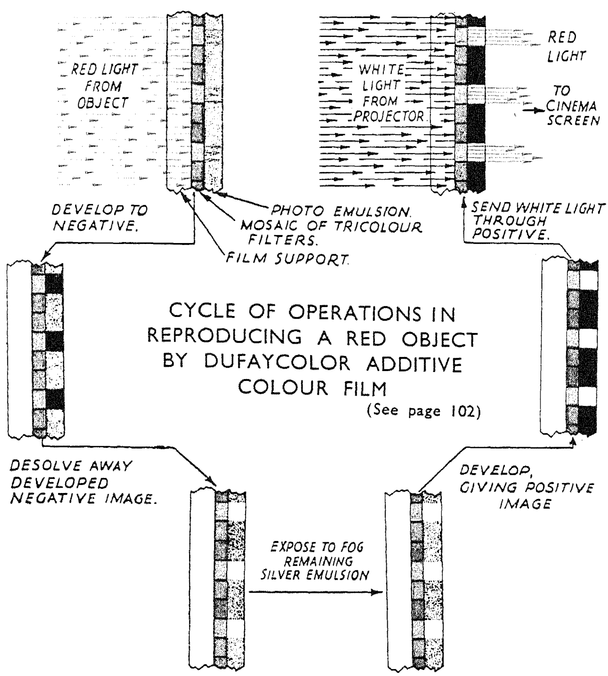

CYCLE OF OPERATIONS IN REPRODUCING A RED OBJECT BY DUFAYCOLOR ADDITIVE COLOUR FILM

(See page 102)

THE PAGEANT OF PROGRESS

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THE CINEMA TO-DAY

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CHAPTER I

INTRODUCTORY

THE printed Zoetrope strips which entertained our grandparents in their youth having been relegated to the shelves of curio shops, it may be safely stated that the basis of all present-day cinematography is photographic. Its understanding requires therefore a certain grasp of the elements of photography. Since there are a large number of publications, including a previous volume of the present series (*Photography To-day*), from which this knowledge may be obtained, no chapter on the fundamental facts of photography has been included in the present volume, and it is assumed that they are to some extent familiar to the reader.

Photographs may, of course, be presented for inspection either as opaque prints on paper or as transparent prints on glass, celluloid, or some such substance. Still photographs—especially amateur snapshots—are usually finished as paper prints destined for the frame or the family album. The facts that a few advanced amateur workers finish some of their products as lantern slides for showing by projection, and that colour transparencies are becoming increasingly popular, have not been overlooked when we state that in still photography, generally speaking, opaque prints are the rule and transparent ones the exception. The opposite is the case with the moving picture. Opaque prints flipped rapidly can be used for individual viewing —witness the Mutoscope machines at any pleasure resort—but the projection of transparences is the usual practice. But this non-essential difference should not be allowed to distract attention from the close relationship linking the still camera to the cinematograph camera and the magic lantern to the cinematograph projector (Fig. 1).

A cinematograph camera is in essence a still camera equipped for making a very rapid succession of exposures, and a cinematograph projector is really only a

quick-firing magic lantern. The quickness of the projector (backed by the quickness of the camera) deceives the eye. The eye, like all recording instruments, suffers from certain limitations. Among these is inertia. A certain very brief time elapses between the formation of an image inside the eye and the reception by the mind of a full impression regarding it. A considerably longer interval—about one-fourteenth of a second—elapses, at

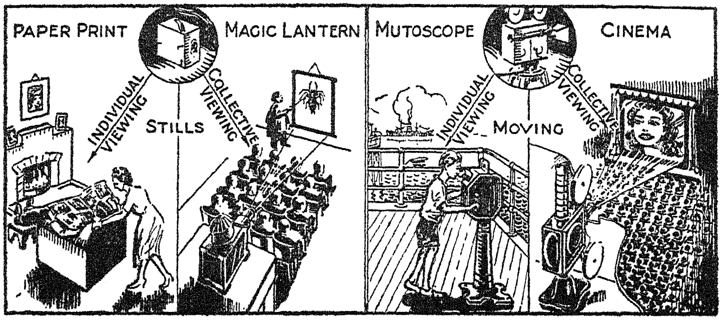


FIG. 1.

the other end of the process, between a change in the image and the instant when the mind grasps that the previous impression is already out of date.

The time-lag in perception leads to two optical illusions directly relevant to our subject—in fact, essential to the existence of cinematography as at present practised. In the first place we get the impression of an unbroken flow of images from what is really an interrupted flow of images, provided that the interruptions are brief enough. We can demonstrate this to ourselves by blinking intentionally. We can feel the eyelids meet, and we know, therefore, that the eyes must for an instant have been completely closed, but the objects which are before them do not disappear even momentarily, provided that the action is performed with normal speed. In point of fact the eyes are, of course, constantly blinking of their own accord, but we none the less enjoy an apparently uninterrupted view of the world.

In the second place, when we look at an object which, having appeared in one position, disappears and re-

appears in another slightly different position, we get exactly the same impression as we should have got if we had seen it actually moving from the first position to the second, present all the time, and occupying on the way an infinity of intermediate positions.

A simple example of this illustration is furnished by a type of neon advertising sign (Fig. 2) which consists of two arrows, *A* and *B*, one just in front of the other, which light up in rapid alternation. Our common sense

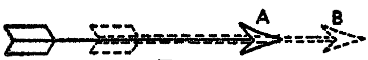


FIG. 2.

can tell us when we examine the sign that it is only capable of showing us first one arrow in one position and then another arrow in another position. Nevertheless, when the sign is actually working we cannot escape the impression that we are looking at a single arrow darting to and fro, urging us imperiously into the doorway to which the sign has been attached. Some uncontrollable part of our mind seems to realize that our senses would not in any event be rapid enough in their working to distinguish between two luminous arrows being rapidly created and annihilated in turn and one luminous arrow being moved from point to point, and to accept as most in accordance with general experience the one-moving-arrow explanation, though it happens in this case to be incorrect.

Were it not for this readiness of the eye to overlook pauses, provided that they are sufficiently brief, and to assume movement as the easiest explanation of anything being first in one position and then in another, the problem of reproducing records of movement in a manner convincing to the eye would probably be an insoluble one. As things are, the inertia of vision enables us to deceive our senses in a useful and agreeable manner. For the essence of all cinematography is simply this: that we present to the eye a rapid succession of stationary scenes, each differing slightly from the next, and the mind mistakes this broken sequence of numerous 'stills'

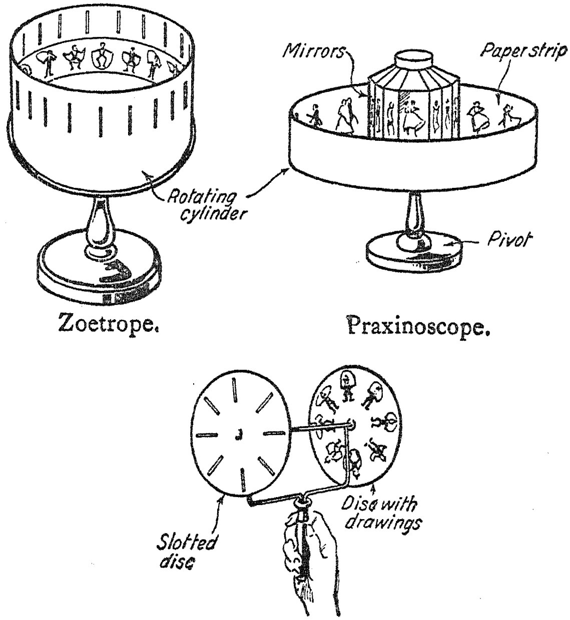
for an unbroken view of a single scene in which certain objects move.

The solution of the problem of cinematography is, therefore, owing to the eye's inertia (usually referred to as 'persistence of vision'), simple enough in theory. In practice, of course, it was not found simple to devise apparatus which would function efficiently at the required speeds. As so often happens, the independent progress of several arts and sciences contributed the various items required for practical working out of the problem. There can, therefore, be no answer to the question, 'Who invented cinematography?' It would be as reasonable to ask, 'Who built London?'

FIG. 3.

The first scientific approaches to the subject date back to observations on a result of persistence of vision which we have not yet had occasion to mention—the fact that a rapidly moving object, such as the spoke of a revolving wheel, is registered by the eye as a transparent blur. In 1825 Roget, emerging momentarily from the compilation of his famous *Thesaurus*, drew attention to the fact that if a revolving wheel is viewed through a fence (i.e. a series of vertical slots) the individual spokes become visible again, but appear deformed. Shortly afterwards, Faraday became interested in this type of phenomenon, and demonstrated the illusions obtainable by viewing the teeth of one revolving cog-wheel through the gaps between the teeth of another. Experiments of this type rapidly became popular, and soon after 1830 a number of scientists independently reported the fact that if instead of observing a series of identical spokes or cogs one observed a series of simple pictures, each a little different from its neighbour, then curious illusions of movement might be obtained. For example, the men shown in Fig. 3 appear, when viewed through a series of moving slots, to take

their heads off and hand them round. The position of the circle of pictures relative to the circle of slots could be varied in a number of ways, some of which involved the use of mirrors, and several such devices were patented between 1830 and 1840 and dignified with classical sounding titles ending in scope or trope. Fig. 4 shows three examples of which the Zoetrope is perhaps the best known.



Phenakistoscope.

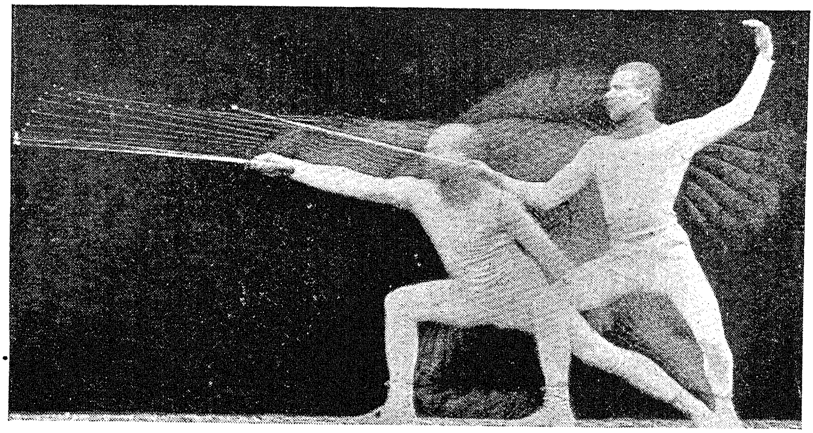
FIG. 4.

This was a hollow drum with slits cut round the top. On the inside wall of the drum, below the slits, a band of drawings each showing some phase of a movement was painted. By spinning the drum and looking at the figures through the slits a very presentable illusion of motion is produced. In 1838 these forerunners of the modern cartoon film were projected on to the screen at the London Polytechnic. A fine collection of these diagram illusion toys may be seen in actual operation at

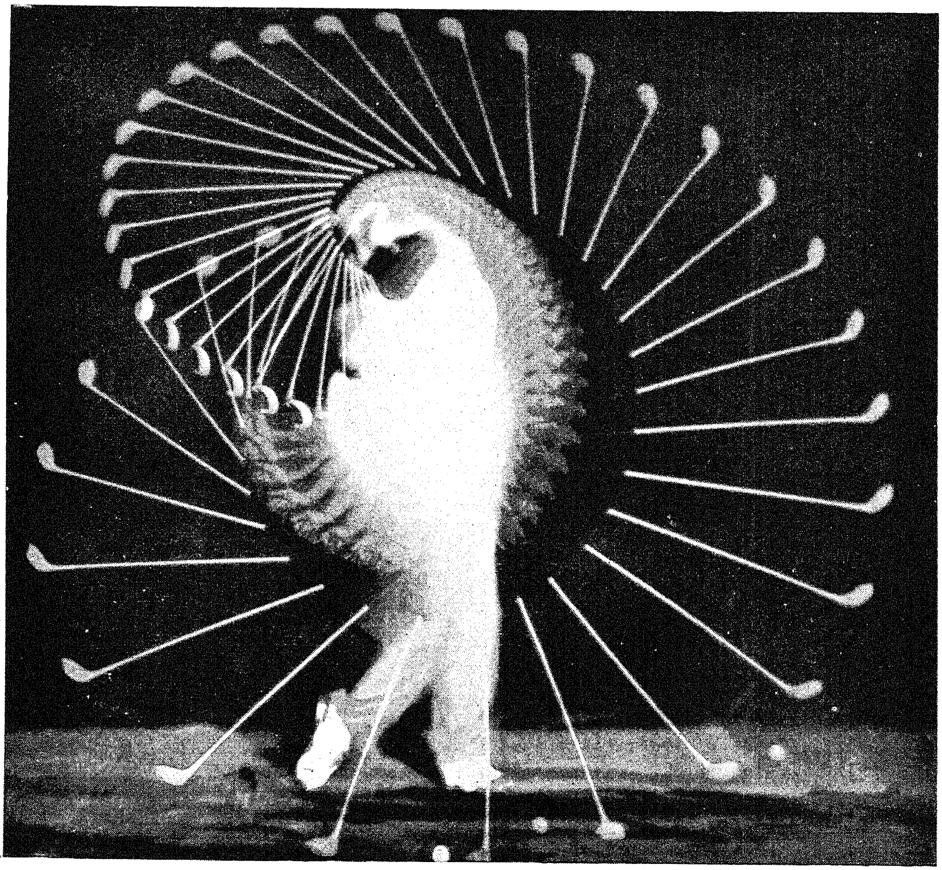
the Science Museum, South Kensington, London, in association with numerous historical relics of the early days of cinematography.

It was, of course, quickly realized that the virtue of viewing through a slot lay in the fact that the viewed picture had only time to move an inappreciable distance during the brief moment of visibility, and so whatever could be accomplished by brief glimpses of a series of pictures rushing by continuously could in theory be better accomplished by stopping the pictures for rapid inspection at very brief intervals. The idea of what an ideal moving-picture-viewing apparatus would have to perform was in fact beginning to be clearly understood. Yet over fifty years were to elapse before the general progress of science enabled cameras and projectors to be constructed which could win the race against the eye's finite, yet considerable, speed of perception; before the inertia of photographic materials (their weight and limited sensitivity to light in particular), which worked against the designer, could be reduced to a less considerable factor than the inertia of the eye, which favoured the designer's attempts. The last twenty of these fifty years were not, however, years of entire stagnation for our subject. From about 1870 onwards several scientific workers, spurred on by the then increasing speed of emulsions, were applying photography to the analysis of movement, both astronomical and physiological, and from present-day perspective their apparatus falls into line as rudimentary cinematograph apparatus.

One of the earliest of these instruments was the 'astronomic revolver' of Janssen by means of which he recorded the transit of Venus across the sun's orbit in December 1874. His pictures (Fig. 5) were taken on a circular glass plate exposed through two shutter disks, one pierced with a single aperture and the other with twelve apertures. The sensitive plate was moved intermittently by a Maltese-cross movement (thus anticipating modern projection practice in one important point) and the shutter disk ran geared in the same

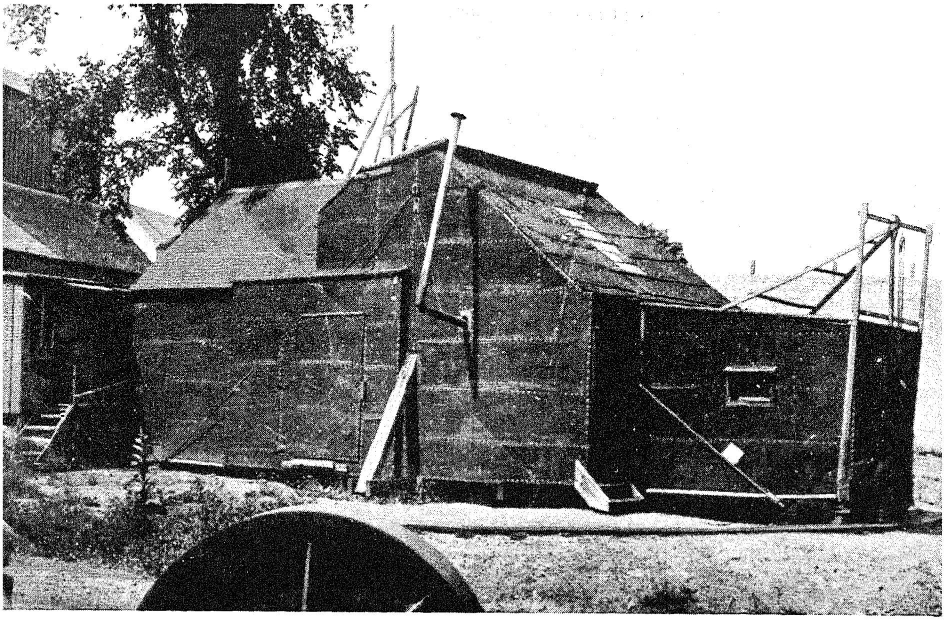


A Fencer's Lunging, by Marey. Exposures of successive positions on a single plate by means of a rotating slotted shutter *By courtesy of 'Sight and Sound'*

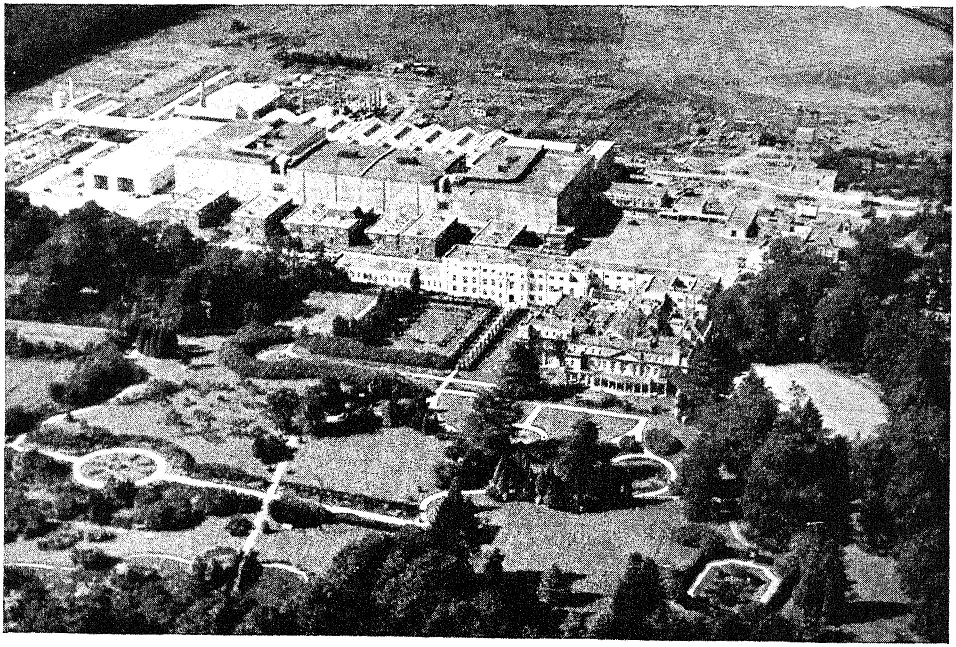


Multi-flash photograph of Golf Drive, taken at the rate of 100 pictures per second. Exposure of each photograph 1/100,000 second

By courtesy of H. E. Edgerton, Institute of Technology, Cambridge, Mass.



The Black Maria: the first Moving Picture Studio in America (Edison Company, 1893)
By courtesy of the Museum of Modern Art, New York



Pinewood Studios, Iver Heath, Bucks.

relation to the plate as the modern cinematograph camera-shutter is geared in relation to the film-movement—that is to say, the openings of the shutter coincided with the stationary periods of the plate. The general conception of the design was, however, clearly derived from the rotating slot-viewed -scope and -trope toys. Forty-eight shifts exposed the whole circumference of the plate, and the speed of picture shifting was considerably slower than that required for cinematography proper. Moreover, the object photographed—the sun—was highly luminous, so that exposure problems were minimized.

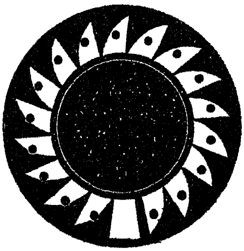


FIG. 5. Janssen's record of the transit of Venus.

The researches of Muybridge, an English photographer working in America, may be cited as another instance of a special technique useful only for the study of a particular problem. His work arose out of a wager between two American millionaires who disagreed as to whether, at any point in its progress, a trotting horse had all four feet off the ground. Muybridge set up a row of twenty-four cameras side by side. As the horse was driven past each camera it tripped a thread attached to the shutter (1872).

Muybridge's photographs settled the question in favour of those who argued for a period of unsupported transit, and he became interested in the possibility of elucidating other obscure points in animal locomotion. His method was limited in its application by the fact that only one picture per camera was produced, while the only subjects that could be photographed were those capable of being induced to move along the ground past his battery of cameras. Nevertheless, by 1885 he had over 100,000 photographic plates of moving men, beasts, and birds, some of which in 1877 he reproduced on bands of paper for viewing in the Zoetrope. He may thus have been the first to combine the illusion of reality given by the photograph with the illusion of

movement which results from viewing a rapid succession of consecutive pictures. Edison was consulted by Muybridge on 27th February 1888 with a view to 'combining and reproducing simultaneously in the presence of an audience visible actions and audible sounds together' by coupling up his apparatus with Edison's phonograph, but the suggestion was abandoned as impracticable.

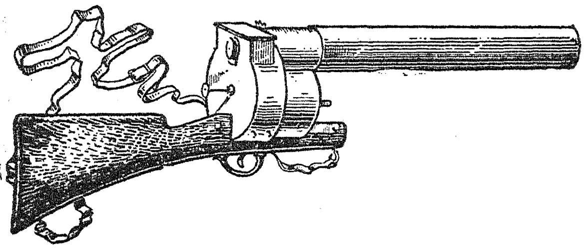


FIG. 6. Marey's Photographic Gun.

The outstanding figure of that period of movement-analysis by means of special cameras, which extends approximately from 1870 to 1895, was Marey, head of the Physiology Research Station in Paris. His investigations covered the movements of men, horses, birds, and insects, and he employed various types of apparatus in accordance with the requirements of each experiment. Subjects that moved their limbs but did not displace themselves entirely were dealt with by the method of multiple exposure on a single stationary plate. The exposures were made through slots on a rotating disk. By this method the picture which would otherwise have been a blur was broken up into a series of sharply defined positions separated by a time interval calculable from the speed of rotation of the shutter. The result was, in fact, a diagram rather than a picture. Plate 1 shows a fencer's lunge treated in this method. For investigating the flight of birds, Marey constructed a photographic gun (Fig. 6) which was modelled on Janssen's revolver. A telephoto lens was mounted in the end of the barrel. For the purpose in view he was compelled, of course, to speed up the interval between

his exposures. Considerations of inertia, accordingly, drastically limited the size of his plate, and the number of images on each plate was twelve only. Fig. 7 shows an example of the results obtained. The exposures employed were in the order of 1/500th of a second, which was a very brief period when the slow emulsions and lenses of that date are taken into account.

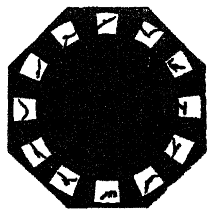


FIG. 7. Positions of a Gull in Flight taken with Marey's Gun.

There was no method of ensuring that the twelve pictures obtained would represent a complete cycle of movements, and Marey was, in 1886, already attempting to prolong the series of images obtainable by designing a camera which should impart an intermittent movement to a flexible strip of transparent paper. He was thus hovering on the verge of modern cinematograph camera design.

On 10 January 1888, Augustin le Prince was granted British Patent No. 423 for the employment of perforated gelatine film to reproduce, by a sprocket-actuated movement, a rapid sequence of images taken through a single objective and, in October 1888, le Prince projected moving photographs on to a screen. These photographs were, however, recorded on strips of paper joined together by a red film backing with perforated margins. Le Prince's combined camera and projector was built at Leeds and is preserved at the South Kensington Science Museum. In 1890 he left Dijon by train for Paris taking with him his latest model. What happened to him on, or after, that journey is still an unsolved riddle, for no trace of him or his apparatus has since come to light.

Neither paper nor unsupported gelatine is a suitable material for cinema film, and the modern era dates from 1888, when celluloid in a form suitable for photographic purposes became available. Numerous experimenters in America, England, France, and Germany who had been held up hitherto by the same obstacle—the lack of a

tough, flexible, structureless, unstretchable, transparent support for photographic emulsion—brought their designs to the point of practical performance with a simultaneous rush.

In England, William Friese-Greene learned of celluloid from Alexander Parkes of Birmingham who had discovered the material in 1865, and on 21 June 1889 Friese-Greene filed what is considered by many to be the master patent in the art of cinematography.

This patent describes a camera and projector both having an intermittent movement, a single lens, and using sensitized celluloid film in the form of a ribbon with perforated edges. The camera was exhibited to the Bath Photographic Society in February 1890 and films made with the apparatus were projected at Chester later in the year. A very full account of the apparatus appeared in the *Scientific American* in April 1890. This report was of considerable importance to Friese-Greene, for it clearly described the function of the loops in the film on either side of the film gate, and the American Supreme Court upheld Greene's prior right to a patent when Edison subsequently made this one of his own main claims.

Unfortunately, Friese-Greene, though a born experimenter, was a poor business man deaf to the voice of worldly wisdom. Throughout his career one half-perfected design followed another in surprising but unprofitable succession, and his worldly possessions amounted to a few coppers when his death took place in 1921 at a meeting concerned with the development of the subject to which he had given his life.

Edison first became interested in the possibility of cinematography in 1887. According to Dickson, who carried out much of the practical work, 'The idea, the germ of which came from the little toy called the Zoetrope and the work of Muybridge, Marey, and others', was to combine the phonograph cylinder with a larger drum on the same shaft which was to carry tiny microphotographs to be viewed by a microscope. In 1888 the drum was abandoned in favour of strips of

celluloid. George Eastman, founder of what is now the Eastman-Kodak Company, was experimenting in the manufacture of large sheets of celluloid; his interest in this possible application of long lengths of celluloid was easily aroused, and by 1889 Dickson and Edison were also making cinema films on celluloid.

Although Edison came to Europe in 1889 and possibly saw projected films in England, he had little faith at that

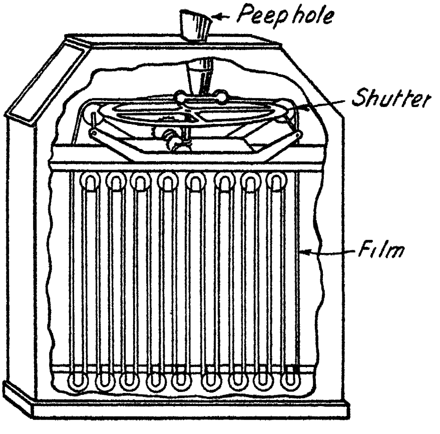


FIG. 8. Edison's Kinetoscope.

time in the projected image, and on his return concentrated on improving his kinetoscope (Fig. 8), in which an endless loop of moving film was directly viewed through a peep-hole. The film travelled continuously and was illuminated by electric flashes which were so timed that each succeeding picture on the strip of celluloid was seen only at the moment when it occupied exactly the same position as the preceding picture when illuminated by the preceding flash.

The kinetoscope was among the exhibits at the Chicago World's Fair, 1893. Yet it is to be noted that this instrument was merely a slot-viewed peepshow devoid of intermittent movement—a glorified version of the old rotating toys. Edison's improvements lay in two facts: firstly, that he had constructed a camera

capable of providing photographs in lieu of drawings, and secondly, that the endless band of film in his viewer provided hundreds of images where the cardboard disk could provide tens only.

Jenkins, who later founded the American Society of Motion Picture Engineers, financed by Armat, built in 1890 a camera using celluloid film; it was followed in 1894 by a projector which threw the moving image on to a screen. The apparatus was shown to the agents of Edison's kinetoscope, but they displayed no interest until Jenkins set up his projector at Atlantic City opposite an 'arcade' in which kinetoscopes were installed. Business was taken away from the arcade, and Jenkins's interest in his invention was bought up—one of the conditions being that Edison's name should be attached to the apparatus for 'publicity reasons'.

Far more curious things have been done in the name of 'publicity' during the subsequent development of commercial cinematography, and it must be pointed out that the kinetoscope was the first machine capable of being turned to commercial account.

It may be worth adding that the film width and arrangement of perforations which Edison adopted for this machine have survived the test of time and are those of the 'standard film' now in use throughout the world.

The first pictures to be shown publicly by projection were very poor entertainment; the image flickered and danced about on the screen, and the photographic quality was exceedingly poor. The flicker was due to the alternating light and dark intervals on the screen, and remained a great drawback until Pross, in 1903, devised a three-bladed projection shutter which inserted additional dark intervals during the projection of each image. In this way, without increasing the actual number of pictures projected per second, the number of separate images which reached the observer's eye was multiplied by three, and flickerless projection resulted.

As early as 1895 the cinema had become more than an amusing sideshow in a fair, and gave hints of the rapid development that it was soon to achieve.

In fact, a writer of that date, taking stock of the situation as he saw it in 1898, states flatly that in 1895 moving-picture apparatus 'reached its final form'. The assertion may raise a smile nowadays, though it is more nearly true than might be imagined. The only very obvious difference between a film made to-day and one made forty years ago is the presence of the sound-track running in a narrow ribbon down one side of the film. This track, a photographic graph of the sound waves, is, however, nearly always recorded by instruments which form no part of the picture camera, and is transferred to the film by printing it from a separate negative during processing. Subsequent improvements, so far as picture projection is concerned, have been matters of detail, not of principle. But it is not in terms of mechanical perfection that the importance of cinematography to the world of to-day must be measured. Its most remarkable characteristic is the multiplicity of functions, some merely decorative, some strictly utilitarian, which it fulfils in the fabric of the modern State. It would, in fact, be difficult to compile a complete list of the aspects from which cinematography might at the present time reasonably be reviewed. To the apparatus-designer film is a material which has to be handled in long strips. To the scientist and amateur enthusiast it is a recording and reproducing instrument. To the salesman, whether of goods or ideas, a method of publicity. To those who are concerned with the moral welfare of every one else, a problem. And to the world in general—mass-produced entertainment.

It will clearly be impossible to treat all these aspects, and a variety of subsidiary ones, at all fully in this volume. We can only hope to give a rough outline likely to interest those who desire a bird's-eye view of the subject, together with some clues which those who wish to scrutinize some particular field more closely may care to follow up. Nevertheless, within the available limits, we have borne in mind as far as possible the desires of those who, when looking at a watch, echo with Helen's Babies their desire 'to see the wheels go round'.

CHAPTER II

THE CAMERA

FIGS. 9 and 10 show very much simplified diagrams of an instrument simple in any case—the box camera, designed for taking still photographs on roll film.

Figs. 11 and 12 show equally simplified diagrams of a somewhat less simple instrument—the cinematograph camera. Fundamentally, both perform the same function—that of moving a flexible strip of film past a lens and letting first one section of the strip and then another stop in front of the lens. But the still camera is only required to perform this task quite slowly and with little precision, while from the cinematograph camera both high speed and high precision are expected. The more elaborate construction of the cinematograph camera results solely from these requirements. In the still camera the film is simply drawn from roller *A* on to roller *B* by turning the handle *H* until a new number appears in the window *J*. It makes no difference to the efficiency of the camera that the turning-on process takes several seconds to complete and that the distances moved by the film on each occasion may be only approximately equal.

The cinematograph camera, on the other hand, has to effect at least sixteen shifts a second and halt the film after each shift with great exactitude if projection is to produce a steady picture. This rapid start-and-stop motion necessitates that the weight of all moving parts should be kept low, and accordingly cinematograph film is a narrow ribbon less than an inch and a half wide. Accurately punched sprocket-holes along its edges enable it to be moved with precision by suitable mechanism.

The mechanism employed in all cinematograph cameras is a claw (*G*) which moves forward and enters the perforations, then moves downward carrying the film with it, and then withdraws clear of the film and moves up again to repeat the cycle. A 'pilot' pin which

enters a perforation and steadies the film during its stationary phase is a refinement usually incorporated.

Narrow though the film is, the lengthy strip required for cinematography possesses considerable weight, and it is necessary to interpose what we may describe as buffers between the delicate action of the claw and the

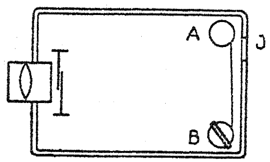


FIG. 9.

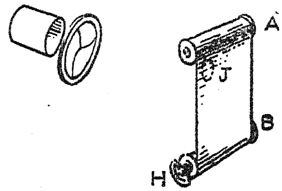


FIG. 10.

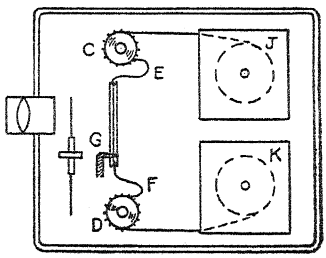


FIG. 11.

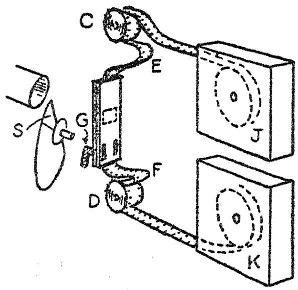


FIG. 12.

drag of the main bulk of the reel, whether from above or below. The buffers take the form of toothed wheels (*C* and *D*) in engagement with the perforations. These wheels, which are called 'sprocket wheels', run at a level speed and thus keep pace evenly with the feed of the film from and to the spools *J* and *K*. Loose loops of film *E* and *F* are left between the sprockets and the 'gate', as the passage is called through which the claw drags that portion of the film which is actually being exposed. A flickering motion of these loops absorbs the difference between the steady feed of the sprocket wheels and the intermittent feed of the claw.

The cinematograph camera, like the still camera, requires a shutter to keep light from reaching the film except during the desired periods of exposure. Since in

cinematography the desired periods of exposure bear a definite relationship to the film's phases of shifting and stopping, the shutter is geared on to the film-propulsion mechanism in such a way that its open sector passes the lens only while the film is stationary. The camera mechanism is generally so designed that the exposure periods and shift periods are about equal. Thus the normal exposures are 1/32nd or 1/48th of a second, according to whether silent film or sound film is being taken. An adjustable segment (*S*) can be added to the solid part of the shutter to enable the exposure period to be shortened when an object moving rapidly across the field of view is being photographed, for in such circumstances normal exposure might be too lengthy and result in blurred effect. For the most part, however, correct exposure of the film is obtained by regulating the 'aperture stop', the device which, as in a still camera, controls the effective expanse of the lens, considered as a circular window.

The rotary shutter, with its alternate phases of exposure and non-exposure, is generally speaking a satisfactory device, but where similar phases in the movement photographed repeat themselves at rapid intervals, as in the rotation of a spoked motor-wheel, an illusion is liable to be introduced that the spoked wheel is going round the wrong way, owing to a chance relationship between its phases and the phases of the shutter.

Our imaginary cine-camera of Figs. 11 and 12 would, if a viewfinder were added, be a workable instrument. Indeed, for about twenty-five years cinema cameras of this simple type were widely sold at prices ranging from fifty shillings to fifty pounds and used by amateurs and professionals all over the world. A few instruments surviving from this epoch may be seen to-day in the hands of those kerb-side photographers who spring out on the casual passer-by with the news that he has just become the involuntary subject of a snapshot. The main drawback of such a camera is that hand-cranking is impossible unless a substantial tripod is available, and even then will not provide the accurate

speed-control required for sound film. Accordingly, all modern cameras are fitted either with spring-drives or electric motors, the latter being synchronously interlocked with the electric drive of the sound-recording mechanism.

Another usual refinement is the provision of a rotating turret for a lens mounting. This enables lenses of different focal length to be brought into position rapidly. Lenses designed for use with standard film may have focal lengths ranging from 1 inch to 40 inches. A 2-inch lens is the one normally employed. The 40-inch telephoto lens shown in Plate 3 was specially constructed for newsreel use at the Coronation of King George VI. Natural history work also benefits from the use of telephoto lenses.

As the cinematographer cannot prolong his exposures to meet the conditions where the lighting is inadequate, he requires lenses capable of working at a wide aperture. His lenses of shorter focus may have apertures as wide as f 1·4—that is to say, a 2-inch lens would have an effective diameter of nearly an inch and a half and a working speed about sixty-four times faster than the lens fitted to an ordinary box-camera.

In addition to such conventional lenses, specialized types have been developed whose focal length can be altered during the actual filming.

A typical lens of this type can be progressively altered from a focal length of 40 mm. to one of 120 mm. by altering the distance apart of the front and rear components of the lens. This is done by rotating a crank coupled with a dial whose pointer shows the alteration in magnification which is taking place. The reader is probably familiar with the effect which is obtained, but may have assumed that when a distant scene gradually comes nearer, the camera has been moved towards it. The camera is of course moved when it is convenient—the camera being mounted on a truck or on a crane-arm which can be swung about the studio. When, however, it is necessary to follow an actor through a doorway or a window, actual movement

of the camera becomes impracticable, or at least very difficult, and the variable-focus lens used on a stationary camera is employed instead.

It will be convenient, in describing the design of present-day cameras, to deal separately with those taking 'standard' film 35 mm. wide, which are mainly used by professionals, and those taking sub-standard widths (16 mm., 9·5 mm., or 8 mm.), which are mainly used by amateurs. The range of sub-standard apparatus, both cameras and projectors, will accordingly be dealt with in a later chapter.

The design of 35-mm. cameras has for some time past branched out in two different directions: suitability for use in outdoor work, and suitability for use under studio conditions. The first type (known as the 'automatic') has tended towards simplicity and lightness, the second towards increasing size and complexity. The automatic camera, being spring-driven, can be held in the hand when necessary, though the hand is never as steady as a tripod, and this fact becomes painfully obvious when long-focus lenses are used which emphasize any shakiness of the camera's support. The compact size and independent working of the automatic camera endow it with a wide range of uses. For example, it can be left on a railway line running itself while a train passes over, and the result on the screen will be a pleasing illusion that the train has run over the cameraman.

Recently, for the purposes of an educational film, it was desired to show just how a plough turns the earth up. This was satisfactorily accomplished by fastening an automatic camera on to the actual body of the plough with its lens pointed downwards.

Studio cameras are, of course, motor driven, and are almost invariably encased in an outer box called a 'blimp', which deadens the camera noise and prevents it from being picked up by the microphone and recorded on the sound record.

Great importance is attached in modern film-production to constant change of viewpoint as a means of

achieving variety and rhythm. These effects necessitate not only that the camera should be mobile on its support but that the support itself should be capable of locomotion. Vertical 'tilting' and horizontal 'panning' are provided for by suitable elaborations of the familiar camera tripod, but 'tracking' shots in which the camera actually travels along while in action require the use of a little vehicle called a 'dolly' (Plate 7), which accommodates not only the camera and cameraman but also his assistant who, among other jobs, has to maintain correct focus while the 'dolly' perambulates. Sometimes, in order to obtain bolder movement and a more sweeping view, the titanic contrivance called a camera crane (Plate 7) is called into action. Hoisted aloft by this strange structure, the camera and its crew can defy gravity and hover over the scene at will.

A more lofty bird's-eye view is of course obtainable from an aeroplane. Generally speaking, however, aerial shots are made from so great a height that little detail is distinguishable. An exception to this rule was the record of a cup-tie match obtained by newsreel cameramen some years ago following on a disagreement regarding the terms on which filming within the enclosure would be permitted. Helicopter planes and telephoto lenses solved the problem.

The problem of making films under water might at first sight appear overwhelming, but actually it was successfully tackled as far back as 1914 by a marine engineer, J. E. Williamson, who designed a spherical observation chamber slung from the bottom of a ship by a flexible metal tube large enough to act as an entrance passage (Fig. 13). The clear waters and prolific marine life of the sea off the Bahama Islands furnished ideal scope for his operations, and the film of the Williamson Submarine Expedition created considerable enthusiasm among audiences all over the world. More recent submarine photography has been carried out by divers equipped with a submersible camera.

An important attribute of cinematography is its power to deal high-handedly with the limitations which

beset our normal perception of moving objects. We can enjoy the extraordinary experience of applying the accelerator or the brake at will to the visible universe around us by the simple expedient of working our camera at one speed and our projector at another. For reasons which will become apparent in a later chapter

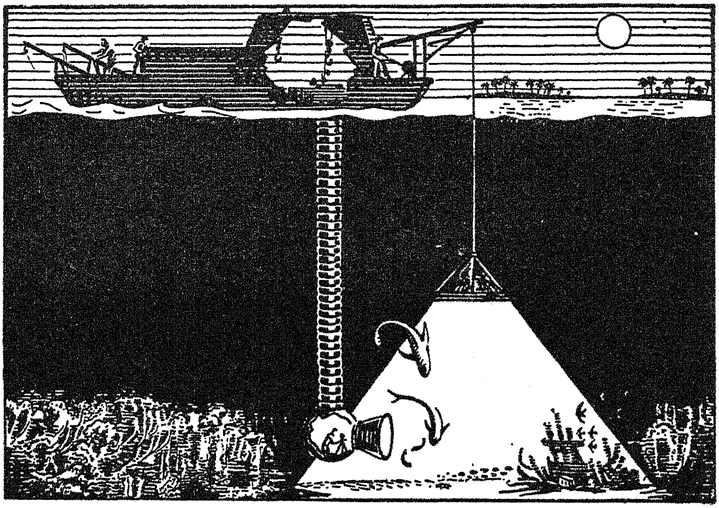


FIG. 13. J. E. Williamson's Submarine Apparatus.
(*From 'Twenty Years Under the Sea', by courtesy of J. E. Williamson.*)

the speed of the projector must conform to drastic limitations, and it is therefore on the camera that we find that choice of speeds which produces such miraculous results.

Variations of camera-speed may conveniently be classified into those within the compass of a camera constructed on normal lines and those which require specialized design.

A normal camera may be geared down to about eight pictures a second or geared up to about a hundred.

Slowed-down camera-speed may be useful either as a means of lengthening the exposure periods of the film, and so compensating for bad lighting conditions, or of

obtaining the comic effects which may result from a slight speeding up of ordinary actions on the screen.

For example, some years ago use was made of this trick in a newsreel item recording the annual race between Covent Garden fruit porters, each staggering under a towering and swaying stack of baskets. The touch of exaggeration thus bestowed on their already astonishing prowess raised a general laugh.

The comic effects will be in abeyance when the scene depicted contains little action, and it is accordingly in these circumstances that the device may be used simply for lengthening exposure.

Moderately accelerated camera-speed (with its resultant slowish motion on the screen) is generally used as a means of enabling the eye to follow movements which would otherwise be somewhat too rapid to follow with ease, such as the gait of animals, boxers in action, and various other kinds of sport, dance steps, or the breaking of waves on the shore. Moderate slow-motion of this kind may serve the purposes of research, as when the actual sequence of an animal's movements is ascertained; instruction, as when the correct action in some kind of sport is made clear; or illusion, as when events supposed to be seen in a dream are given a tinge of romantic unreality by slow motion.

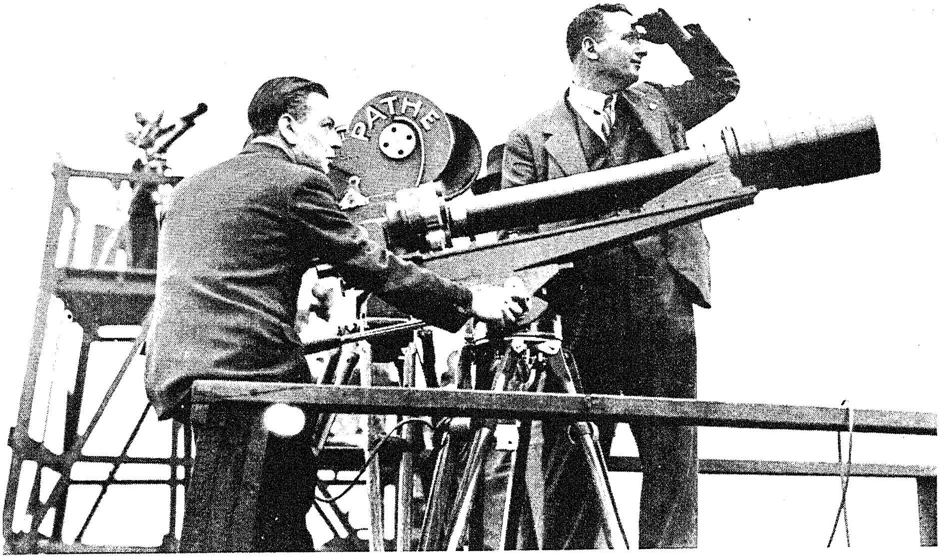
The speed range we have been considering, which demands no fundamental variation of camera construction, extends from about half normal speed to about six times normal speed.

The slowing down of the camera required for such subjects as the growth of a plant lies between one-hundredth and one-hundred thousandth of normal speed. That is to say, the camera may sometimes be required to make only one picture per hour. The installation which accomplishes this is called a stop-action camera, and consists essentially of an ordinary camera combined with a clock and a source of electric current in such a way that the clockwork makes an electric contact at regular intervals, and the current then turns the camera mechanism through the phases neces-

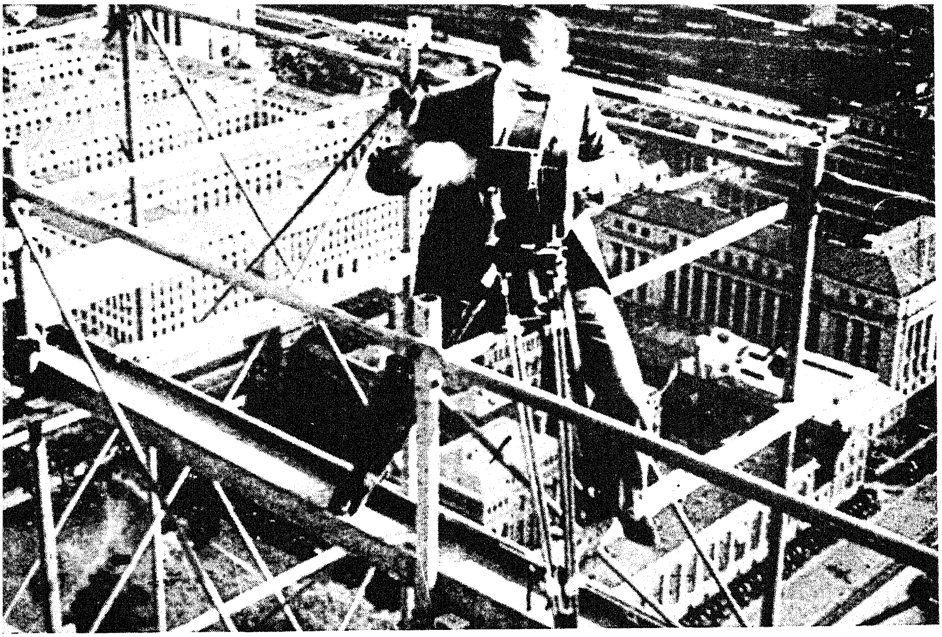
sary for a single exposure. In addition to these essential elements, it is almost always necessary that a number of subsidiary contrivances should be put into action by the spurt of current which turns the camera. For example, it invariably switches on a battery of suitable lamps, since natural daylight, fluctuating between each exposure, would produce a most disagreeable flickering effect on the screen. Clearly, moreover, absence of daylight is necessary for uniform photographic effects by artificial light, but presence of daylight is necessary for the growth of a plant. Consequently the current which flows at each exposure must in such cases be made to pull down the blinds round the subject before the exposure is made. The case of photographing root growth is even more complicated. Here, of course, it is not daylight but darkness and complete embedding in soil which the growth requires. An ingenious and elegant solution of this problem was found by Percy Smith, a pioneer worker in time-lapse photography, whose contributions to the *Secrets of Nature* and subsequent *Secrets of Life* nature films are well known in almost every country which possesses the means of showing films. He sandwiched the roots in a thin layer of earth between a brick and a block of peat, and hinged the peat block in such a way that an electrically worked mechanism swung it away from the brick every time an exposure was made.

It may be interesting to note that some wholly unexpected and very curious facts were demonstrated by means of the film so made. For example, it was found that the roots showed an uncanny awareness of obstacles about to be encountered and headed away from them before actual contact. Further, it was confirmed that this faculty resided in the actual tips of the roots, as roots from which the tips were severed were seen to prod blindly against small stones before turning aside.

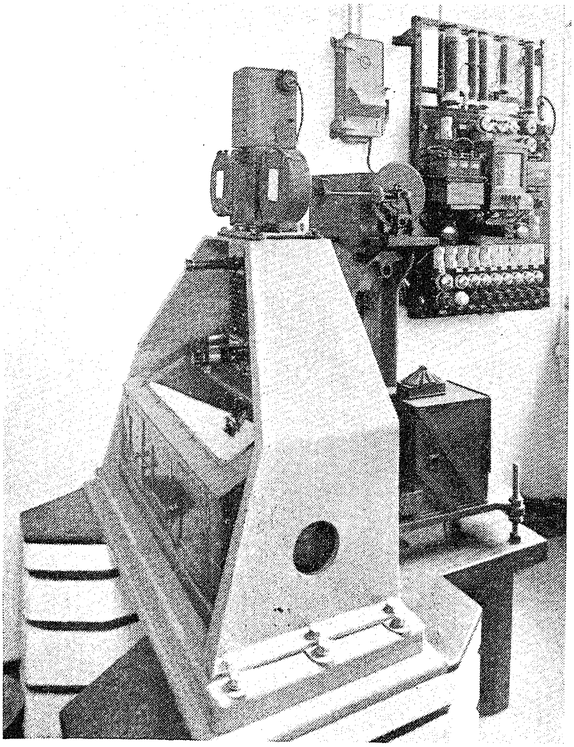
Incidentally Mr. Percy Smith's apparatus, which belongs to that class of inspired amateur contrivance which, very unjustly, it is at present fashionable to



Giant Pathé lens—the largest cine lens in the world



All in the day's work: a cameraman in Washington taking a picture from the top of a scaffolding 400 feet above the roadway *By courtesy of Pathé Gazette*



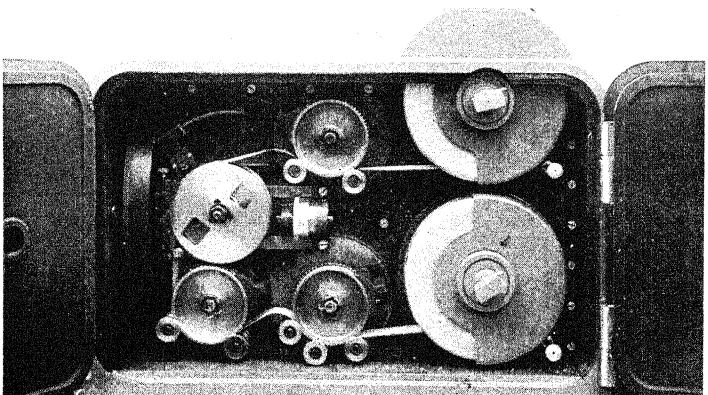
Time-lapse Camera

The time-lapse photomicrograph installation at St. Bartholomew's Hospital on which the late Dr. Canti made his films of tissue-growth in connexion with cancer research

At the bottom are seen the tiers of concrete blocks alternating with sheets of sponge rubber which insulate the microscope from vibration. The glass case resting on the main platform is the incubator in which the tissue-cultures are kept alive. The microscope itself is partially concealed by the massive iron casting which serves as a solid perch for the camera

The camera drive and its immediate controls are seen just behind the camera, while the remote controls, including the timing-clock, are fixed to the wall (top right corner) *By courtesy of 'Sight and Sound'*

(*ABOVE*) ONE PICTURE EVERY 5 HOURS, (*BELOW*) 3,000 PICTURES EACH SECOND



Interior of Vinten high-speed camera for continuous film-movement with optical compensation. At the extreme left is seen the edge of the wheel which carries the ring of forty-eight travelling lenses. Note the rotating back of the gate

Photo by courtesy of Messrs. W. Vinten, Ltd.

deride by references to the drawings of Mr Heath Robinson, includes an electric bell which rings automatically in his bedroom if anything goes amiss with the working of the machine during the night.

The time-lapse camera installation which has produced the most important scientific results is perhaps the one constructed for the late Dr. Canti by the British Empire Cancer Research Fund (Plate 4). With its aid, Dr. Canti made films which threw much valuable light on the details of those fundamental processes that underlie the building up of living tissue, whether healthy or diseased.

The difficulties which had to be overcome before such a film could be made were very formidable.

In the first place, a high degree of magnification had to be used, which meant that vibration must be avoided, since obviously one cannot exaggerate the size of an object without also exaggerating its movements if it is shaken. Accordingly, alternate layers of sponge rubber and concrete were used to support the massive cast-iron struts on which the camera and microscope rested.

Photographic difficulties centred round finding a suitable source of light, giving high intensity from a small source. An over-run 'Pointolite' enclosed tungsten arc was found to give the best results. Even so, it was extremely difficult to avoid killing the tissue culture by excessive radiation when enough exposure for photographic purposes was given.

Stop-action installations such as these are the modifications of an ordinary cinema camera employed when such extremely slow camera-speed is required that, in fact, the camera is out of action most of the time and only makes an exposure at intervals.

The core of the apparatus is an ordinary cinema camera, and the modifications are extraneous pieces of mechanism which have to be linked up with the camera for the purpose in hand.

Ultra high-speed cinematography, on the other hand, requires the radical redesigning of the camera itself. If the behaviour of a projectile on impact with armour

plating or the spread of the explosion in a car cylinder requires to be followed in detail, then the movement on the screen requires to be quite a hundred times less fast than the actual movement photographed. This means that the film must rush through the camera at about a mile a minute, a speed which effectually rules out the possibility of its normal method of progression—alternate stops and starts. Accordingly, it becomes necessary to build into the camera moving optical devices which send the images formed by the lens streaming along in synchronism with the rush of the film. Thus, for a very brief moment, as film and images flow together, each image is stationary in regard to the film and leaves a clear-cut impression on it. The optical devices employed may be rotating rings of lenses, as in the Vinten high-speed camera shown in Plate 4, or rotating plane prisms, as in the Western-Electric-Kodak camera, Fig. 14. Such cameras will record up to 2,500 pictures a second.

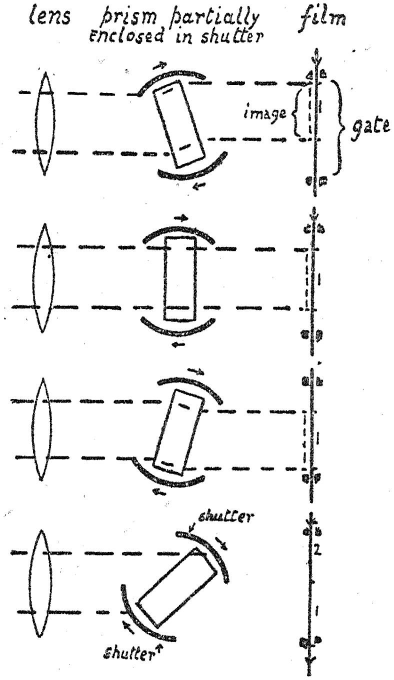
In the Vinten camera a very exact time-scale for the reading of these photographs is obtained by fogging a spot on the edge of the film at intervals controlled by a vibrating tuning-fork. Similarly an ordinary clock, whose action will then appear much speeded up, may be included in the field of view of a time-lapse camera.

An alternative technique to using a moving image and a moving film which are stationary with respect to each other is sometimes made use of in the laboratory.

The film runs through the camera continuously and no shutter is employed, but instead the object being photographed is illuminated with a succession of brilliant flashes of light, each of such short duration that as many as 6,000 may be crowded into one second. During the time that each flash (sometimes obtained by discharging electrical condensers through mercury vapour lamps) illuminates the object, the film will not have moved appreciably through the gate and a sharp image is, therefore, obtained. Plate 1 shows a photograph taken in this manner, but on a stationary plate.

High-speed films of fast or complicated movements enable these to be slowed down when projected to such

a speed that the eye is able to see and the mind to comprehend. Obscure but important details are thus revealed, while measurements can be made at leisure showing the position of the various parts as a function of time and analysis made of such movements as golf strokes. Thus the club velocity before and after impact,



Frame I moves down into the gate aperture, where it is covered by the upward refracted beam.

Frame I moves down the gate aperture, the image following it as the prism rotates.

The image follows frame I to the bottom of the gate aperture.

The shutter cuts off the image, while frame 2 moves into the top of the gate aperture.

FIG. 14. Rotating plane prisms in Western-Electric-Kodak camera.

the ball velocity, and spin, can all be calculated from the photographs, although the ball and club were actually in contact for less than 1/1,000th second. High-speed photographic study of an automatic tapping machine gave results which indicated the advantage of a particular working-speed. The spray from solid injection Diesel jets showed the form of the charge from differently shaped jets as the charge diffused through the chamber.

Provided that the movement is rotary or vibratory, an analysis of the movement can be recorded in slow

motion by means of an ordinary cine-camera by illuminating the object with stroboscopic light, that is, flashes of light which occur at the same frequency as the motion to be studied. The use of the stroboscope depends upon the persistence of vision of the eye. Since the eye sees the object at only a single instant during each cycle, it receives each view of the image at the same relative instant of the cycle and the object appears stationary and can be photographed at leisure. If, however, the interval between the flashes is slightly longer than that required for one complete cycle of the regular movement in question, each succeeding flash will illuminate a slightly later phase of the movement. As a result, when viewed or photographed by means of such a series of flashes, the movement appears to have been slowed down, a single record of the complete cycle being selected by the flashes from perhaps a hundred actual cycles.[1] The flow of air through a fan-blade is an example of application of this method, smoke being fed into the air stream to make air currents visible.

Another interesting field in which specially designed cinematographic apparatus is employed is astronomy. For some ten years now the McMath-Hulbert Observatory at Lake Angelus, Michigan, has been engaged on making cinematographic records of disturbances taking place on the surface of the sun (Plate 11).

Still pictures recording momentary aspects of the storms around sun-spots and the gaseous prominences which rise for many thousands of miles above the solar surface had of course been in existence for many years. But the moving record reveals characteristics of these phenomena which are puzzling to the physicist and promise to be of great importance in astrophysical research.

An obvious difficulty in photographing local dis-

[1] If the flashes occur at slightly shorter intervals than the complete cycle, the cycle will appear to be moving in reverse. This effect is often seen on the screen when vehicles start or pull up. Here, of course, each spoke moves into the position occupied by the one in front during the period between the exposures.

turbances on the sun is to avoid the dazzling effect produced by the general brilliancy of the sun's surface. Fortunately the solar prominences have a great preponderance of certain elements (calcium and hydrogen) in their composition, and this difficulty can therefore be solved by the use of a specially adapted spectrograph. By fitting suitable masks in the spectrum into which the sun's light is spread by this instrument, only calcium and hydrogen light is transmitted to the camera.

With an exposure of 27 seconds and a period of 3 seconds between exposures, 2 frames will be exposed per minute. This leads to a speeding up on the screen of 480 times. In the actual circumstances of the case this compression factor turns out to serve a useful purpose.

Suppose, as is not at all unusual, that a bright knot is seen to form 100,000 miles above the solar surface and then to descend at the rate of 40 miles per second—about average as solar prominence velocities run, but still 80 times the speed of a high-power rifle bullet. Its total time of descent to the sun will be 42 minutes. Instead of having to wait this time in our seats to see the history of this descending knot, we see a summarized version of events which takes 5 seconds only, and a scene which is made up of several such knots in motion will occupy the more convenient period of 20 to 25 seconds.

Among other refinements in equipment which cinema work was found to demand from the astronomer was an improved method of telescope drive, since existing methods were found to introduce too wide a margin of error as to the position of the image on the film, and an unsteady picture resulted. The method which finally solved this problem was based upon an infinitely flexible and instantly variable control of the input electrical frequency to the telescope drive motor, secured through resistance-ballasted thermionic valves.

As a final example of cinematography requiring a special layout, X-ray work may be cited.

In order to appreciate the difficulties which beset

X-ray cinematography, we must bear in mind that the usual X-ray pictures which are often described as 'X-ray photographs' are, more strictly speaking, 'shadowgraphs'. That is to say, no lens and camera went to their making. The outline of the bones and other opaque structures or objects in the body was recorded directly on the plate in somewhat the same way as the outline of a picture hung on a wall is recorded by the fading of the wall-paper.[1] The natural tendency of an object's shadow is to be larger than the object itself, so that it may easily be imagined that this method is not suitable for producing normal film pictures, which are smaller than a postage stamp. Nor is it possible to solve the problem by putting an ordinary camera in the path of the X-rays, as the rays would treat the light-proof walls and bellows of the camera with scant respect, penetrating straight through them to fog the film. Indeed, the only part of the camera through which the X-rays would find it difficult to pass would be the lens. The way out of the difficulty lies in the use of a fluorescent screen which converts into light some part of the stream of X-rays which impinges on it. These light-rays can then be used to produce an image in a cinematograph camera in the usual way, provided that the body of the camera is screened from stray X-rays by a suitable lead casing. The fluorescent screen converts a small proportion only of the X-rays, and consequently it is difficult to obtain sufficiently exposed pictures by this method unless special provisions are made. Lenses of aperture up to 0·85 are used, and experiments have been made in constructing special cameras with quick film-shifts and long exposure-periods. Each of these expedients has, however, its own inherent limitations. Such lenses necessarily have a very shallow depth of focus, and the prolongation of the camera exposure involves a prolongation of the time during which the subject being photographed has to undergo the effects

[1] Actually the exposure of the resulting shadowgraph is brought about by the light emitted by a phosphorescent tablet in contact with the emulsion as described later.

of intense irradiation. A synchronized switch connecting the X-ray tube with the camera mechanism cuts off the activity of the X-ray tube while the film in the camera is in motion, and in this way the tissues of the subject are allowed time to recuperate from the effects of each exposure.

Since the 'moving parts' are among the most important constituents of the human mechanism, photographs of the functioning of the internal organs have great importance for medical science. It may be said, in fact, that there is hardly any branch of science which can afford to dispense entirely with the cinematograph camera as a recording instrument, and on this aspect of cinematography we shall have occasion to touch again. The uses mentioned in this chapter have merely been those that involved special problems in the design of the camera.

Among future possibilities in the evolution of camera design we must include an electron camera incorporating the devices which have been worked out in connexion with the Emitron cameras used in television.

Such a camera would by photo-electric means convert the image formed by its lens into a stream of electrons carrying a current fluctuating in accordance with the lights and darks of the image being scanned. The current could then be magnified to any desired amplitude, and either produce a latent image by direct bombardment of the sensitive surface by the electrons, or be converted back again into a visual image by fluorescence or otherwise, and finally recorded on a light-sensitive emulsion.

The theoretical advantage of such a method would be, of course, that low levels of illumination might be dealt with by the electric amplifying factor introduced, our present approach to this problem being limited to the widening of the lens aperture and the increasing of the emulsion sensitivity.

CHAPTER III

SOUND RECORDING

SOUND consists of pressure waves travelling through air whose frequencies lie between 20 and 10,000 or more cycles a second. The waves are started in the first place by the vibration of solid bodies such as violin strings or of columns of air as in wind instruments. We hear a sound because the waves hit our eardrums and cause them to vibrate. Sound-waves will cause any suitably stretched membrane to vibrate in a similar manner, and in the gramophone and sound-film we record these vibrations in a permanent form and in a way that will enable us at some later time to reverse the process.

There are four commercially practical methods of recording sound:

(1) *Mechanical.* Wherein the recording and reproducing are done mechanically.

(2) *Mechanographic.* Wherein recording is done mechanically and the reproducing optically.

(3) *Photographic.* Wherein recording is done photographically and the reproducing is done optically.

(4) *Magnetic.* Wherein the recording and reproducing are both done magnetically.

All these methods were visualized by inventors long before they became commercially practical. Since in recording sound a measurement of a ten-thousandth of an inch is a large measurement, the progress towards perfection of each system has had to await the solution of problems connected with the perfection of materials and auxiliary equipment, such as the vacuum-tube amplifier. The early inventors were no more capable of making a successful sound picture than Leonardo da Vinci was of building an aeroplane before suitable engines were developed and the knowledge of aerodynamics had been extended. Since with primitive apparatus it is easier to achieve a 90 per cent. efficiency with (1), this was the first system used for linking sound recording with the film, all the experience of gramo-

phone recording being available as a basis. Edison himself firmly believed that, without sound, the moving pictures would never be more than a side-show in a fair, and he coupled up his earliest machines with his phonograph; but it was not until October 1927, when Warner Brothers' *Jazz Singer* electrified Broadway and threw the whole cinema industry overnight into a turmoil, that the linking of the film with the gramophone record received any serious attention.

Although the sweeping success of these early sound-on-disk talkies was such that almost overnight the standard studio equipment became out of date and many of the 'silent' stars themselves faded into oblivion, the recording of sound on a separate gramophone record was soon abandoned for the more satisfactory sound-on-film systems. Some of these still depend upon a mechanically cut sound-track, however. Thus in Russia, where there is a large bulk of silent film available, a diamond cutting stylus is still used to cut a mechanical sound track down the side of the film. The instrument which cuts this track can be used for reproducing the sound by substituting a needle for the stylus, and in remote villages where the only electricity available is that from tractor accumulators, the system is of considerable value. In another form of mechanically produced sound track the cine-film is coated down one edge with a thin band of opaque material 1/10th of an inch wide. A sapphire gouge whose edges make a very oblique angle with the film surface is used to cut a hill-and-dale transparent sound-track in the opaque band. The shape of the track resembles that obtained in variable area recording (Fig. 19) and it is reproduced by the method described below, but has the advantage that, since no processing of the film is involved, the track can be 'played back' if necessary immediately after it has been recorded.

The magnetic method of recording has not as yet been applied to the making of sound-film and need not, therefore, be described.

Practically the whole of present-day commercial

sound-film depends on the photographic recording of the sound, the pressure vibrations which constitute sound being translated into photographic images recorded on a narrow strip situated between the picture area and the perforations of the film and called the sound-track. In recording sound in this way and later reproducing it again as sound, the energy involved undergoes a number of transformations which are illustrated diagrammatically in Fig. 15. It will be seen from this diagram that the variations in air pressure which constitute sound are first transformed into varying electrical currents. In ways to be described, these currents are then used to vary—or, as it is usually termed 'modulate' —a beam of light which is then used to prepare a photographic record. In order to reproduce the sound, a beam of light is projected on to the film record in the form of an optical image of a slit, and the sound-track as it travels past this slit forms a continually varying photographic mask which controls the amount of light transmitted by the film at any point. The modulated light then falls on a photo-electric cell, a kind of synthetic eye, which converts the various intensities of light back into varying electric currents. These, when sufficiently amplified, actuate the diaphragm of a loud speaker and so reconstruct the original sound.

The first step in the cycle is to receive the sound waves in a microphone wherein the pressure waves falling on a diaphragm produce variable electric currents whose variations correspond to the variations in the sound waves received. The microphone is a truly remarkable instrument; if all the people on earth were talking at once they would not generate enough power to drive a motor-car along a smooth road at 30 m.p.h., and yet a microphone operates with but a part of the power of a single voice, and translates this power in such a way that its original wave-form is preserved. In a typical microphone a thin disk of metal carries a piston which presses against a loosely packed collection of carbon granules through which the current from a battery is passing. The ease with which the current

passes depends upon the closeness of the packing of the granules, and so each compression wave as it arrives causes a momentary increase in the flow of electricity through the circuit.

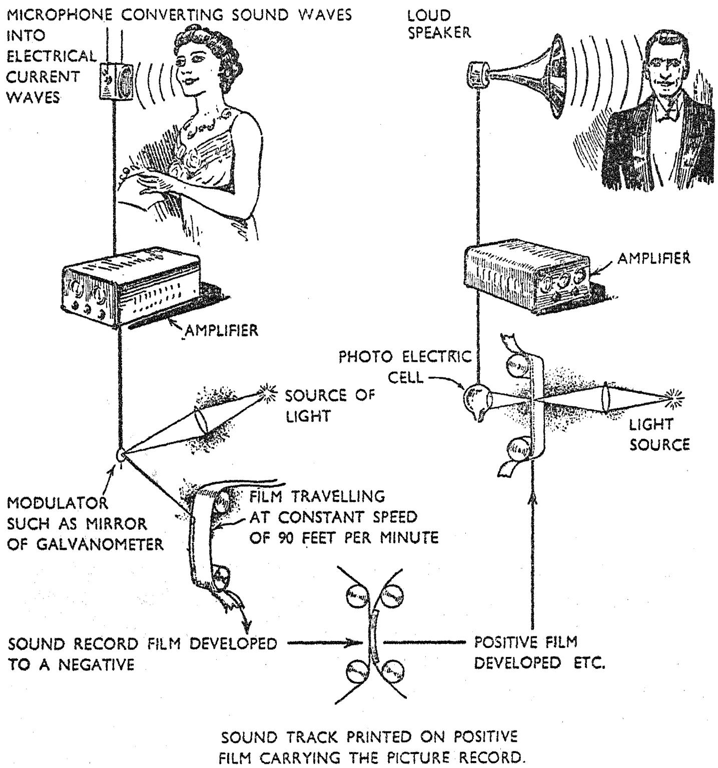


FIG. 15.

Another form of microphone increasingly used for sound-film recording consists essentially of a pair of plates, one of which is fixed and the other movable under the action of sound-waves. These plates form an electrical condenser whose capacity varies as the distance between the plates varies. The minute variations in current in the condenser circuit which result from these alterations in its capacity are amplified by amplifiers of the vacuum-tube type, and are then used to modulate

a beam of light which is then projected on to the area reserved for sound recording down one side of the moving film. This modulation can be carried out in a number of ways, of which perhaps the most obvious is to cause a glow-lamp to flicker in sympathy with the vibrations of the microphone diaphragm. The light source in the glow-lamp is a narrow line (about 1/50th of an inch wide); it is focused on the moving film by an optical system which reduces its area about thirty times. On developing the film a 'sound-record' is obtained

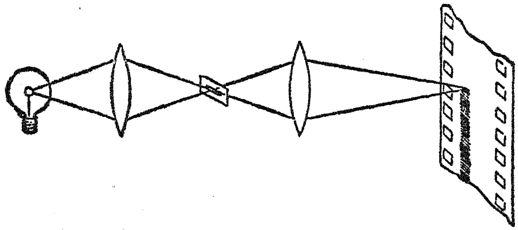


FIG. 16. Variable Density Sound Recording.

which can then be printed on to a positive film, where it appears as a series of short parallel lines of varying opacity corresponding to the original sound vibrations (Fig. 16). Such records are known as variable-density records, and there are several other methods of producing them. One of these is known as a light valve, which consists essentially of a slit between two tiny strips of aluminium. As the strips vibrate in a magnetic field which varies in accordance with the varying current received from the microphone, the width of the slit varies in a corresponding manner, allowing varying amounts of light to fall on the recording film. Obviously the film takes a certain fixed time to travel from the top to the bottom of the light slit, and any variation in sound occurring over this interval will not be recorded as such, the film recording the 'average' sound over this tiny interval. However, by arranging that the lower ribbon of a light value moves a fraction of a second after the upper ribbon it is possible to arrange that exactly the same section of film is affected by similar movements of the top and bottom of the slit.

This technique for avoiding 'slit loss' is known as phase shift.

In order that each variation in intensity or area of the sound-controlled light source may be individually recorded, it is necessary that the portion of the film on which sound is recording be moving continuously past the slit. Accordingly, when, as in news cameras, the sound and picture are both recorded on the same film, the sound record is made on the film after it has passed the two sprockets between which its travel is intermittent. The film is moving past the slit at about 1 foot per second, and if a distinctive record of each individual wave is to be obtained, the slit must not be more than 1/1,000th of an inch wide. It would be very difficult to keep an actual mechanical slit of such dimensions free from dust, &c., and accordingly the tiny thread of light which actually falls on the film is an optically reduced image of a conveniently large actual slit.

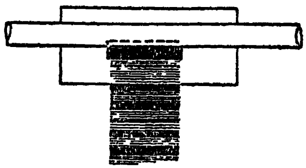


FIG. 17. Variable Density.

Another method of producing variable density sound records is illustrated in Fig. 17. Here a shutter, in the form of a taut wire, is used to vary the width of the slit. The wire lies between the poles of an electro-magnet, and when currents from the microphone flow through it, the wire moves aside in response to the vibrations produced in the electro-magnetic field, and corresponding variations in the amount of light falling on the film take place. In order that the variations in density of the sound-track shall be an exact translation of the variations in pressure which formed the original sound, there should be a linear relationship between the brightness of the recording light and the photographic density of the corresponding record on the film. Unfortunately, this relationship is not linear over the complete range of densities which the film is capable of recording, since very low and very high brightnesses do not show an equal rise in density for each equal increase in exposure. Unless, therefore, the exposure and processing of the

film are kept within very narrow tolerance limits, distortion of the sound-record becomes marked. Moreover, when this sound-record is printed on to the positive film, the characteristics of the positive sound record are controlled by the fact that the positive film must be processed to give an acceptable picture, and photographer readers will appreciate that this may mean that the sound-track itself may not then lie, as it should, within the limits set by the straight-line portion of the characteristic curve of the emulsion. For these and other reasons variable density recording is gradually falling out of favour, the so-called 'variable area' systems taking its place.

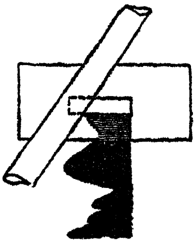


FIG. 18. Variable Area.

Whereas in variable density a beam of fixed dimensions has its intensity varied (glow-lamp recording), or a beam of constant intensity and length has its width varied (light-valve recording), in variable-area systems a beam of constant intensity and width has its length varied. Here, again, there are several methods of bringing this about. Suppose, for example, that the wire of the system illustrated in Fig. 17, instead of being parallel with the slit, crosses it at an angle, its vibrations will alter the apparent length of the slit so that the record on the film, instead of being of variable density, will be a wavy track of constant density but varying width—the width at any point being proportional to the amplitude of the original sound vibrations (Fig. 18). It is, in fact, a graph of the pressure component of the sound-wave at the microphone, its outline being a picture of the wave shape, on one side of which the film is uniformly black and the other side uniformly clear. The smaller the movement required of the vibrating parts of a sound-recording system, the smaller will be the limitations imposed by their inertia and the more likely, therefore, will be successful reproduction of high frequencies. One way of reducing the necessary movements to a minimum is to make use of an optical lever to magnify them.

Accordingly, a tiny aluminium alloy mirror (less than one millimetre square) is suspended by hair-like wires between the poles of an electro-magnet whose field is modified by the current from the microphone. A triangular spot of light is reflected from this mirror on to a fixed slit, and as the mirror vibrates about its horizontal axis in accordance with the variations in the surrounding magnetic field, the reflected spot dances up and down across the slit (Fig. 19), and as a result there is a corresponding increase and decrease in the length of the slit image which is focused on the film. Moreover, it will be obvious from the diagram that the more acute the angle at which the slanting edge of the spot intersects the slit, the less the movement of the mirror which is necessary to produce the sound-track (Plate 5).

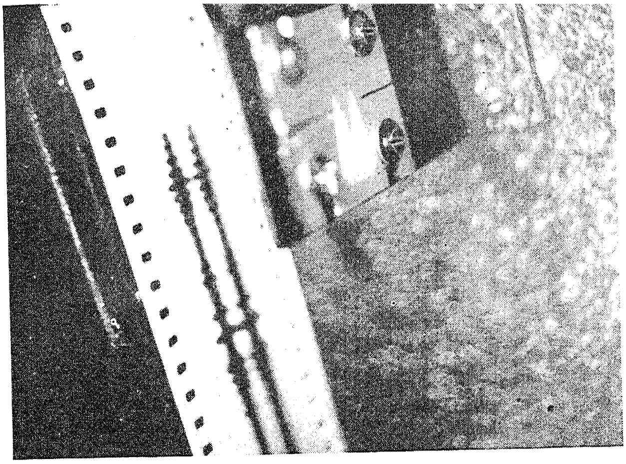
The ideal variable-width record would be one made with a slit of negligible width and with an absolutely sharp border between exposed and unexposed areas. Owing to the width of the slit (about 1/1,000th of an inch) there is a gradation of exposure over a minute distance, and when recording such high frequencies that this distance becomes an appreciable fraction of the wave-length, distortion becomes noticeable. An even more serious cause of distortion is the spreading of the photographic image as a result of light scatter in the emulsion. The photographic emulsion consists of a suspension of microscopic crystals of silver bromide in gelatine. So small are the individual crystals that many thousands could easily be accommodated on the head of a pin. So well dispersed are they in the gelatine support that the emulsion coating is barely translucent. Light entering this fog of tiny particles is scattered by repeated reflections, and as a result, a sharply defined hair-line of light becomes broader and less well defined the farther below the surface it penetrates. Emulsions vary very considerably in their light-scattering properties, but even the most carefully processed emulsion is unable to resolve lines whose images are less than 1/2,000th of an inch apart. Since the scattering power of the emulsion increases with the depth to which the light penetrates,

resolving power is increased if the image is confined as far as possible to the emulsion surface. One way of doing this is to stain the emulsion yellow and make the exposure by blue light. Blue light cannot pass through a yellow filter, and so only the surface layers of the emulsion are affected. (See p. 135, and *Photography To-day*, p. 95.) An even more efficient method is to use ultra-violet radiation for both recording and printing. Although the photographic emulsion is exceedingly sensitive to ultra-violet rays of wave-length 3,000 to 4,000 A., it is also practically opaque to these rays. Accordingly, the whole of the image is recorded in the surface-layers of the emulsion. Incidentally, the use of a narrow band of wave-lengths such as that quoted has the additional advantage that it makes the presence of chromatic aberration in the optical system unimportant.

Accordingly, although, as Kellog has said, 'We have given our painter not only too big a brush, but a piece of blotting-paper upon which to make a picture and paint that runs', research is gradually increasing the faithfulness of sound recording, and considerable care is essential if these improvements are not to be nullified at later stages.

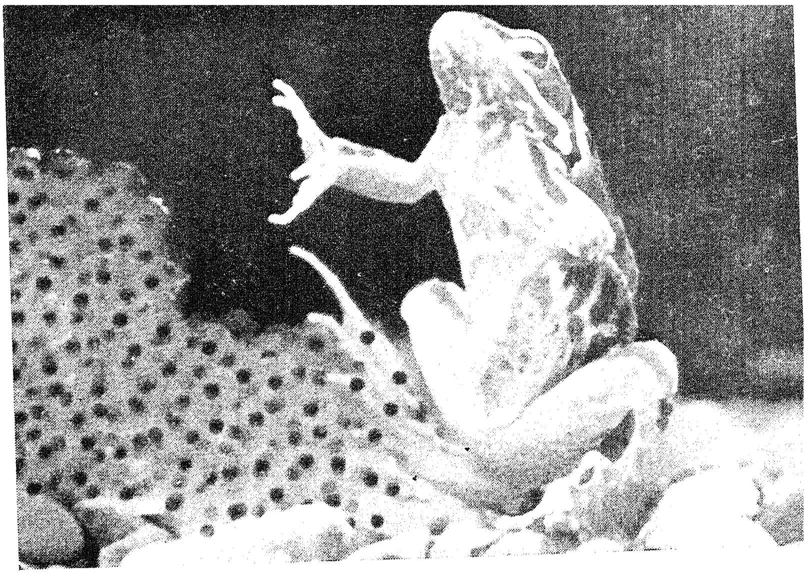
The coming of sound-films necessitated radical changes in the technique of producing, casting, staging, and processing of films, and helped to break the virtual monopoly which America had established in the cinema industry. Cameras had to be redesigned to run as silently as possible; hissing arc lamps gave way to 'inkies'—the giant 10,000-watt incandescent lamps. The studios, which in the silent days had been the noisiest places imaginable, were lined with sound-proof packing; and now, when the red light warns the visitor that 'shooting' has commenced, he will be well advised not to risk dropping even the proverbial pin.

Considerably greater attention had to be paid to the photographic quality of the film itself, for faults in processing tolerated or unnoticed in the picture were unpleasantly obvious in the sound. Even with the most



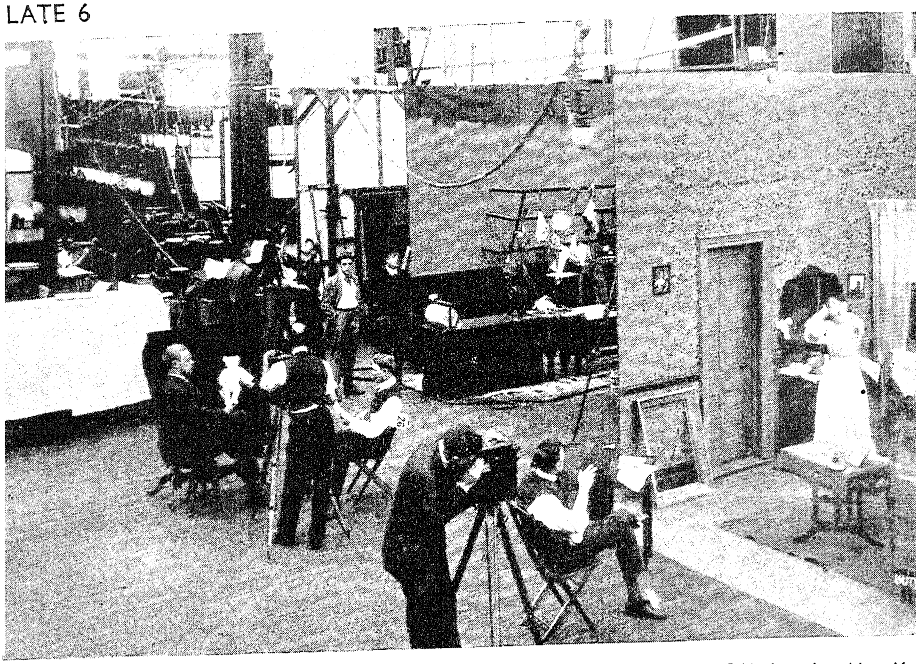
From 'How Talkies Talk', a film describing the technique of sound-recording and reproduction

By courtesy of G.B. Instructional, Ltd.



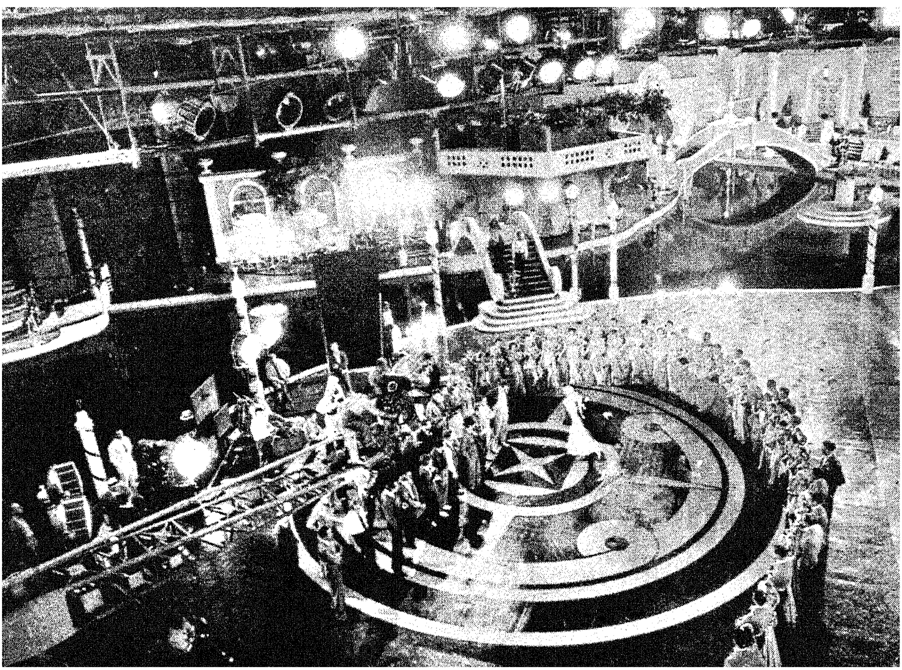
From 'The Frog', a G.B. Instructional Biology Film

By courtesy of G.B. Instructional, Ltd.



Early Film Studio of Edison

By courtesy of Museum of Modern Art, New York



Modern Film Studio

By courtesy of Radio Pictures, Hollywood

painstaking care, pre-talkie technique could not prevent every operation in the processing of the film from contributing its quota to the scratchy, crackling background noise, and development by inspection of films wound on racks like clothes-horses gave way to automatic processing.

It must be remembered that whereas the picture itself is enlarged from film to screen approximately 300 times, the sound is amplified several million times from the initial impulses of the photo-electric cell to the point where it is projected from the loud speakers; and a flaw on the film which on the picture area results merely in a momentary and perhaps unnoticeable spot of negligible size, may produce a deafening crash if it occurs on the sound-record. However carefully the film is processed it is difficult to avoid tiny particles of foreign matter, minute scratches which accumulate dirt, &c., from appearing on the transparent area of the track. As every foreign particle passes in front of the exploring beam it cuts down, for a fraction of a second, the intensity of the light, and it is the presence of a considerable number of such interruptions which results in the so-called 'ground-noise'. Ground-noise is most noticeable during quiet passages, and the principle upon which systems of 'noiseless' recording depend is to lower the average transmission of the film with decreases in the sound-level. In variable-density systems the sound-track is fogged to a predetermined extent during silent passages, while in variable-width recording the area of the clear portion of the track is reduced to the minimum necessary to accommodate the requisite modulation. In the former case this is accomplished by rectifying a portion of the incoming signal and using it to operate a biasing winding on the light-valve ribbons, so that when no sound-current flows they remain closed; the negative resulting is clear and the positive is, therefore, opaque. In variable-area systems this subsidiary current is either used to operate a slow-moving shutter in such a way that the clear portion of the track is reduced to a width that will just accommodate the modulation

Fig. 19 (*c*), or else, in those systems where the moving beam of light in the recorder is triangular in section, by flowing through a biasing winding on the galvanometer,

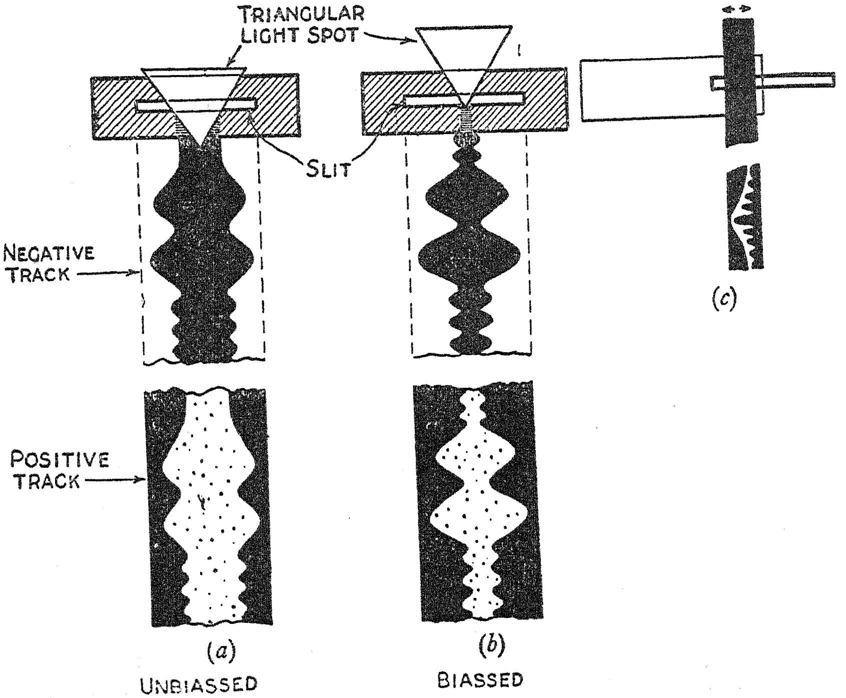


FIG. 19. Two methods of rendering variable-area recording noiseless. (*a*) shows an 'unbiassed' track in which, during silent passages, the light spot is exposing a track of appreciable width, resulting in ground-noise. If, however, a portion of the signal is rectified, it can be passed through a biasing winding on the recording galvanometer and so draw the light spot almost clear of the slit during silent passages (*b*) or else operate a shutter vane to render single tracks such as that shown in Fig. 18 noiseless (*c*).

it ensures that during silent passages only the apex of the triangle is exposing the film. In 'noiseless' recording, therefore, the ribbons of the light valve in the variable-density systems and the spot of light reflected from the galvanometer mirror in variable-area systems

have two separate motions: the first is due to the sound-currents only, and the second is a superimposed movement which follows the envelope of these sound-currents, and is caused by currents corresponding to the average value of the sound-currents at any instant. In the positive print it is the relative width of the trans-

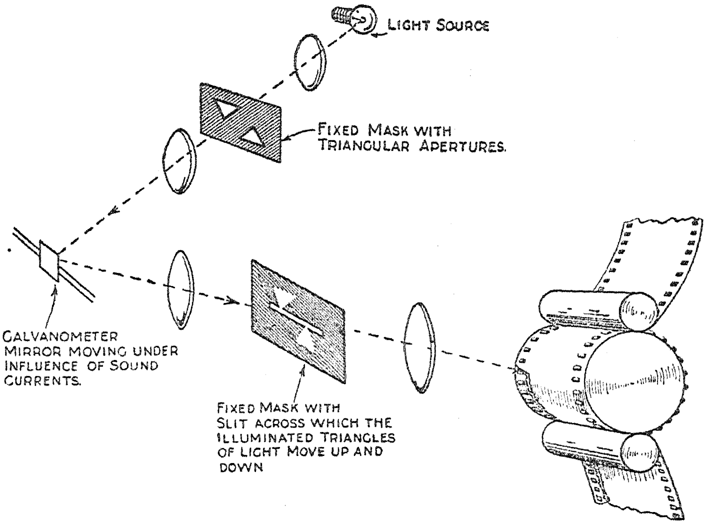


FIG. 20.

parent area between the two halves of the track which determines the pitch of the sound, and by this technique the width of this gap is automatically controlled so that at any moment it is only just wide enough to record the relative variations in the shape of the record, and only foreign particles in this minimum area will now result in ground-noise.

Push-pull Recording (Fig. 20)

In this system ground-noise can, in theory at all events, be reduced to the absolute minimum, because only the area actually occupied by the sound-record is transparent. The single triangular mask illustrated in Fig. 19 is replaced by one with two triangular openings. An optical image of the two opposing triangles is

reflected from the galvanometer mirror on to the slit. The apices of the triangular light-spots are just clear of the slit when the galvanometer mirror is at rest. When modulation of the electric current causes the galvanometer mirror to move, the triangular light-beams vibrate in a vertical plane so that only one light-spot is moving over the slit at any instant. As a result the track which is produced consists of two separate records, one of which carries the positive portion of the impressed wave, and the other, alongside it, the negative portion. In reproduction the positive and negative impulses are electrically recombined to re-create the original sound. As yet, however, push-pull is only used for recording, since theatres are not equipped to play a push-pull sound-track. As, however, on the positive film, the only clear track is that representing the actual modulation, there is a definite gain in recording the sound as a push-pull track and then recording from this a positive track of the conventional type, since other distortions in addition to ground-noise, which are encountered in conventional recording, are balanced out by this system, and it becomes possible to amplify the reproduced sound considerably beyond the limits that would otherwise be tolerable.

Monitoring and Synchronizing

The sound-track is recorded on the film within an area which is 1/10th of an inch wide, and it is important to confine the movements of the edge of the exposing light within this limit. Accordingly, a portion of the light on its way from the light valve or galvanometer mirror to the recording slit passes through a glass plate mounted at 45 degrees to the beam. The plate reflects a portion of the beam on to a white screen which is at such a distance that the vibrating image is greatly enlarged. On this screen predetermined marks show the recording engineer the limits within which the movement of the light-spot must be kept if the sound-track is not to be overloaded.

On the positive film as projected the sound-record is

printed alongside the picture areas, but it is not, of course, necessary that this track should have been recorded on the original picture negative. In the studio, where portability of the equipment is a minor consideration, it is customary to employ two films, one to receive the picture and the other to record the sound, the sound-recording apparatus being quite distinct from the camera. In the reproducing apparatus the film passes successively through the picture projector and the mechanism for sound reproduction. Accordingly, in order that the sound and sight should synchronize, the records are arranged on the film in such relative positions that the two records simultaneously reach the mechanisms for reproducing them.

In order to ensure that, when these two different types of record are printed alongside each other on the final positive, they shall be properly synchronized, it is usual to commence each shot with a visible and audible warning of distinctive character. For example, standing in front of the picture camera an assistant may clap together two pieces of wood, at the same time displaying a board and speaking aloud particulars that will identify the shot. A similar board is photographed by the sound camera alongside the early part of the sound-track and identifies the shot in question, while the exact frame in which the two pieces of wood meet is easily found on the picture record, and the clap causes a quite distinctive smudge on the sound track.

The use of clappers is a rather primitive method of achieving synchronization which wastes film and sometimes has a disturbing effect on temperamental artistes. Accordingly, so-called marker lights are coming into use; that is, tiny beams of light which can be shone on to the edge of both the sound and picture film outside the sprocket holes. These lights, working in series off the same circuit, fog camera and sound-stock edges simultaneously.

The fact that the new method is also more economical in that it requires only an inch or so of film instead of a few feet may seem unimportant until it is pointed out

that it will probably save the industry many thousands of pounds in film alone!

Dubbing and Pre-scoring

One of the first problems confronting producers after it became obvious to them that sound-films were here to stay was the disposal of silent pictures already completed and the conversion of those in production into some sort of sound-film. This problem brought into existence a system called 'dubbing'. The essential operations in dubbing are these. A sequence already photographed is projected upon a screen, the characters who appear in the scene are assembled before the screen, and each at the appropriate moment speaks his lines into a microphone, the voices being recorded on a recording machine electrically synchronized with the projector. The resulting sound-track is then printed on to the picture. It was a short step from this point to the substitution of voices. Just as stars are frequently provided with a double for risky or dangerous stunts, so were vocal 'doubles' introduced to overcome the difficulty of the silent stars with poor voices. Nowadays, however, it is rare for vocal 'doubles' to be used; the stars speak and sing with their own voices. Nevertheless the technique of dubbing has become even more important, since, in 'musicals' especially, it is frequently essential that the sound-record should be made independently of the picture.

It is comparatively easy in a broadcasting studio, where the sound is all that matters, to secure the proper voice quality and balance, because the microphone can be placed in the best position relative to the broadcaster, i.e. directly in front of him. In the film studio such a position is obviously impossible and, at best, the metal ear must be placed above the actor and so situated that neither it nor its shadow will appear on the screen. If the actor must move the microphone must move with him, and the difficulty of avoiding shadows is greatly increased because the majority of the lighting is from overhead. Then again, we are accustomed to listen to

people from a position in front of them, and when their voices are recorded from over their heads there is a definite quality difference in the recording, which is noticeably unsatisfactory if the microphone has to be placed at any considerable distance above the actor's head, as will be essential in 'long shots'. Finally, the assembling of a large cast in lavish settings is an expensive matter, and a 'take' which is excellent from a picture point of view may be a failure as regards sound for any one of a dozen reasons.

All these difficulties can be overcome, and at the same time close-ups and long shots of the action and optimum quality in voices and orchestra can all be obtained, by the technique known as 'pre-scoring'. A typical example of this technique is described on p. 66.

A further gain in quality results from the use of several different microphones simultaneously when recording orchestras. By using separate channels to record the different instrumental groups of an orchestra, each channel being as far as possible acoustically separated from the others, the task of each microphone is simplified, since the microphone recording the violins, for example, does not at the same time have to handle the percussion instruments, and so on. The separate tracks are then combined by reproducing them simultaneously from different reproducers and re-recording the composite sound as a single track.

Reproduction

By whichever method the sound-track is originally recorded, it must obviously be capable of reproduction by a standard type of instrument, otherwise the average cinema theatre would only be equipped for showing films recorded by a particular system. Fortunately, however, all photographic sound-recording systems produce photographic masks whose light transmission at each point varies in accordance with the vibrations of the sound-recording microphones' diaphragm, and it is only with this transmitted light that the sound-reproducing apparatus is concerned. During the projection

of a sound-film the sound-track moves continuously past a slit which projects on it a very narrow beam of light. The amount of this light which is transmitted by the film, therefore, varies rapidly and continuously in accordance with the variations of air pressure which constituted the original sound.

The transmitted light falls on to a photo-electric cell which converts it into electrical energy—a phenomenon with which every photographer who possesses a photo-electric exposure meter will be familiar, although the photo-cell used in sound reproducers is of a rather different type, and instead of operating a galvanometer needle as it does in these meters, the current is enormously amplified and used to actuate loud speakers situated behind the cinema screen. The loud speaker converts electrical impulses back into sound-waves. In a typical speaker a flat cone of parchment is attached at its apex to a coil of wire through which the current received from the amplifier flows. This coil is surrounded by a powerful magnetic field. Any wire carrying electric current which alters in magnitude will move when in a magnetic field, and the greater the variations in the current the greater the movement. Consequently the coil, and hence the cone, vibrate in accordance with the current, and the moving cone gives rise to compression waves in the air which, when they reach our ears, we recognize as sounds.

Modern methods of recording and reproducing sound for films rely for their practicability upon the vacuum tube amplifier. Without amplification the feeble current from the microphone would be unable to produce effects of sufficient magnitude in the recording devices. Without amplification the reproduced current could not operate high-power loud speakers. The distortionless magnification of a sound-bearing current was radio's contribution to the development of the sound film. A modern theatre speaker will convert approximately 25–50 per cent. of the electrical input into sound output over a frequency range of 50 to 10,000 cycles. If the entire frequency range had to be covered by a single

loud speaker severe limitations would be imposed in its design. In general, a diaphragm designed for efficient radiation of low frequencies has too high a mass to be best suited for use at high frequencies, and vice versa. Accordingly the output from the amplifier is frequently distributed between three or more loud speakers, each covering a different range. Usually the sound output is divided at a frequency of 300 cycles, the bass frequencies going to a set of cone speakers mounted in a flared cabinet, while the treble speakers feed into a nest of small horns. In consequence, the maximum output is materially increased without adding to the distortion, and there is an increase in the 'naturalness' of the reproduction. Moreover, by making the horns of the speakers multicellular, each unit can be so designed as to form an ideal channel from the point of view of sound reproduction, while yet directing the sound to every part of the theatre.

CHAPTER IV

MAKING A FILM

You have probably been amused (or irritated) at the transformation a story that has interested you as a novel has undergone when you see its motion-picture version. If we follow the history of a story on its journey from paper to celluloid the reason for this transformation will become clearer.

Whether a particular story is to be turned into a film or not is decided by the producer who is employed by the film company to take complete charge of the making of its films. Every one of the forty-odd departments that will be engaged in making the film is ultimately responsible to the producer. From the moment the story has been listed for consideration until the rough cut version of the film has been finally approved he will, by constant conferences with the heads of the various departments, keep a hold on all the threads and, by thinking a few days ahead of every one else, ensure the smooth functioning of the schedule. Accordingly the producer will read the story first, bearing in mind while doing so the money that will be available for making it into a film, the people who will be available for the leading parts, and the fact that the story must be put over in, say, ninety minutes. Immediately changes will suggest themselves. Some parts of it will have to be sacrificed because it would be impossible to film them satisfactorily, or because it would cost too much, or because they are not really essential to the main theme. It may be necessary to alter the nature of characters in the story in order that the stars the producer has in mind shall be able to cope with the part. If he decides to go ahead the story is handed over to the 'screen writer', who produces a draft scenario which he believes can be filmed in the allotted time and for the allotted cost. This first draft, or 'treatment' as it is called, may be anything from 20 to 700 pages long and relates in more or less narrative fashion how he proposes that the

story be told on the screen. This draft is now discussed with the director whom the producer has chosen, and after such further changes as he may suggest the story is returned to the writer for a final drafting. Most stories are thoroughly mutilated by this time, redundant characters will have been dropped, others combined into one person, whole parts of the book which lack action, being mainly narrative, will be dramatized, shortened, or replaced by entirely new material. In this final draft the story is divided up into sequences, that is, sections of the story each separated from other sections by a fade-out or a dissolve. Each is a playlet in itself, having its own climax and curtain. The writer may offer several alternative methods of treating a particular situation for the producer's consideration, and when the latter has decided the key in which the story is to be told the actual script itself is prepared and circulated to the heads of the various departments.

From now on the producer, in addition to co-ordinating the work of the various departments, will act as critic at every stage, looking at the film from the point of view of its eventual audience; but he will not necessarily take an active part in its making—that is the director's job.

The scenario writer and the director who are responsible for translating the story into cinematic terms must think in such terms. Just as a musician hears the music while reading the notes, so they must visualize the story as they read it in terms of actions, movements, sounds, and dialogue. They must have as a background to their thoughts a whole catalogue of technical devices and effects which will enable them to 'put over' the dramatic situations and mental states of the characters. The success of a picture and its ability to gain and hold the spectators' interest is largely dependent upon the ability with which all these single effects have been interlocked to make a satisfying whole. The mere transposition of a story scene by scene into terms of camera, microphone, and technical trick is not enough any more than is literal translation from one language

into another by the process of looking each word up in a dictionary. And so the director must not only have all the resources of the cinema at his finger-tips, but he must know how to organize them effectively and build the story without calling obvious attention to the bricks he is using.

Estimating then begins. The actors, wardrobe, lighting, building, and special effects required for every set and every scene must be costed, and when, as usually happens, the resulting estimate exceeds the allowable budget, further alterations to the story follow. An average British film will cost about £45,000. One-third of this will be spent on studio rent, equipment, and settings, one-third on the artists' salaries, and the remainder on film stock, running costs, story writers, director's, and stars' fees, insurance, and so on. The next step is to plan the shooting of the various scenes in the most economical manner. It may be, for example, that scenes in which actors appear, other than those that the company has under contract, must all be shot consecutively in order to avoid paying them salaries during the time they are not actually 'on the set'. On the other hand, it may not be practicable to keep an elaborate set occupying a big stage standing idle, and all the scenes on this set must then be made consecutively. As a result, any one who watched the shooting of the picture would probably gather very little idea of the plot of the story.

By this time it is almost certain that the research department will have been called in for advice and information. With the growth of motion-picture appreciation (and classes in this subject are now held in some American schools and colleges), there has been a corresponding increase in discrimination and criticism, a demand for intelligent entertainment accurately presented, and factors which a few years ago could safely be ignored, such as the costumes worn at a particular period in history, the details of scenes supposedly made in foreign countries, and so on, must be beyond criticism. Accordingly every big film organization has

a rapidly growing research department upon which it relies to an increasing extent. The department will have a library of its own and a staff familiar with the big public libraries so that, almost at a moment's notice, they can produce the answers to such questions as 'What sort of hat was worn by Eton boys in 1819?' or 'How did a Crusader salute his superior officer?' In addition, at any moment during the actual shooting this department must be prepared to answer such questions as 'Where can we get a Canadian canoe?' or 'How can we abolish the reflections in a shop window?' but as far as possible such requirements will have been anticipated before the story 'goes on the floor'.

The production schedule is now drawn up and the machinery by which it will be converted into a film can be put into operation. A typical production centre may have five to twenty separate studios, or stages as they are usually called. The larger (7,000–20,000 square feet area) will probably be air-conditioned, built of reinforced concrete, made sound-proof by lining with rock wool or slag wool. These stages are connected to the dressing-rooms and administration block by covered corridors. There will be at least two projection theatres, one of which is large enough to seat two or three hundred people. The centre will almost certainly have its own electric power plant having an output of perhaps 5,000 kw. and providing, when required, 10,000,000 candle-power for stage lighting—enough electricity to light an average-sized town. Serving the studios are a large number of separate departments such as make-up, hairdressing, wardrobe, drapery, modellers' studio, camera repairs, first aid, ornamental plasterers' shop, machine shop, large properties building, small properties stores, sound department, camera department, special effects, film-processing units, cutting rooms, art departments, in addition to legal, accountancy, and publicity departments. Many of these departments are really small factories with, in some cases, as many as twenty separate workrooms.

The sets themselves, i.e. the surroundings in which the actors will perform, commence life as sketches which show both the artistic and the mechanical side of each proposal. From these the art director chooses those he proposes to use, and draughtsmen turn these into blue-prints, frequently incorporating proposals for using stock properties or portions of old sets now finished with. In all probability a model of the set is then built and used by the director, the electricians, the photographers, and so on, to work out the plan of action and the lighting and photographic problems. If, as a result of this conference, alterations are not found to be necessary, skilled carpenters and technicians then build the full-size model. Sets are usually decorated in their natural colours, even for black-and-white films, for this not only helps the actors to maintain the correct atmosphere but simplifies the creation of an illusion of reality, since modern film stock translates the colours of a scene very accurately into the corresponding monochrome brightnesses.

Eventually the day on which shooting is to commence arrives. If the film is to make money for its backers practically every detail in its production will have been anticipated and provided for. Its translation to celluloid is the problem of the head cameraman, and although he does little of the actual photography, the success of the film will depend nearly as much on his ability as on that of the director, for he is the vital link in ensuring that effects which up to now have existed only in the form of rough sketches, written words, or images in the mind of the director are properly translated into the photographs that we shall see on the cinema screen. He must do this by suitable arrangements of the lighting and choice of camera viewpoint, and he will have his hands full in dealing with these problems since he must approach them from a psychological as well as a technical standpoint.

The proper lighting of the set will occupy his attention first, and the actual methods of lighting adopted vary from studio to studio. A considerable amount of

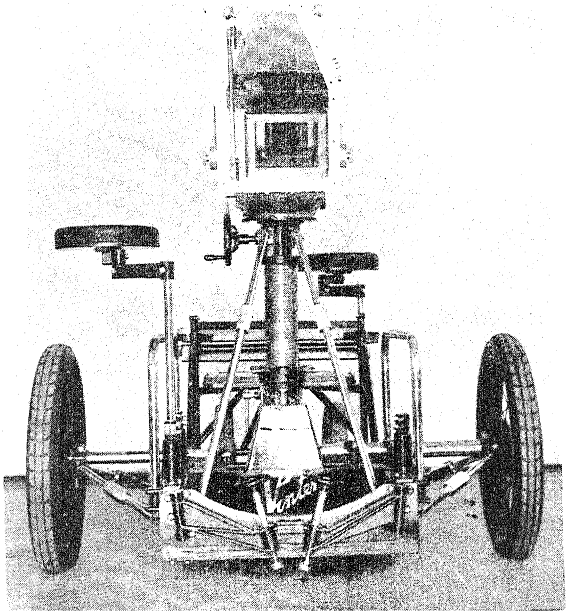
light will normally be required, for each frame of film receives only a snapshot exposure of about 1/50th second. This light must be so distributed that the actors can perform without discomfort; the range of brightnesses from highlight to shadow must not be too great to be recorded satisfactorily on the film; and such points as unwanted reflections or shadows must be guarded against. Arc-light or incandescent gas-filled lamps are the usual illuminants, and in a typical arrangement battens of half-watt lamps are arranged all round the top of the set, and others will perhaps be strung in lines across it. In addition, the camera may be flanked on either side with banks of flood-lights, lamps which give a widespread well-diffused light. These lamps provide a basic shadowless illumination for the set, on which the lighting providing modelling and shadows will then be superimposed. These additional lamps are of many forms, from the 'baby' spotlights used perhaps to introduce highlights into the leading lady's hair to the giant 'sun' arc-lights which, surrounded by parabolic reflectors, will, as their name implies, so light the set that the picture will appear as if made in the open air. Incidentally, the necessity for lighting the actors attractively is one of the reasons why many of the 'rooms' seen on the screen are so much larger than any rooms we live in. The problem of lighting the actors is considerably simplified if they are well away from the walls, and when the chief cameraman comes up against the problem of reality versus the leading lady's face, since the majority of a cinema audience are more interested in the expression and appearance of their favourite stars than mathematically correct lighting, realism often goes by the board. The actual photography is carried out by the first assistant cameraman, who receives his instructions from the head cameraman and is in turn served by assistants.

Another group of technicians is responsible for the sound recording. Before the day's work starts the sound engineer will have examined a test recording which has been made with a valve oscillator and

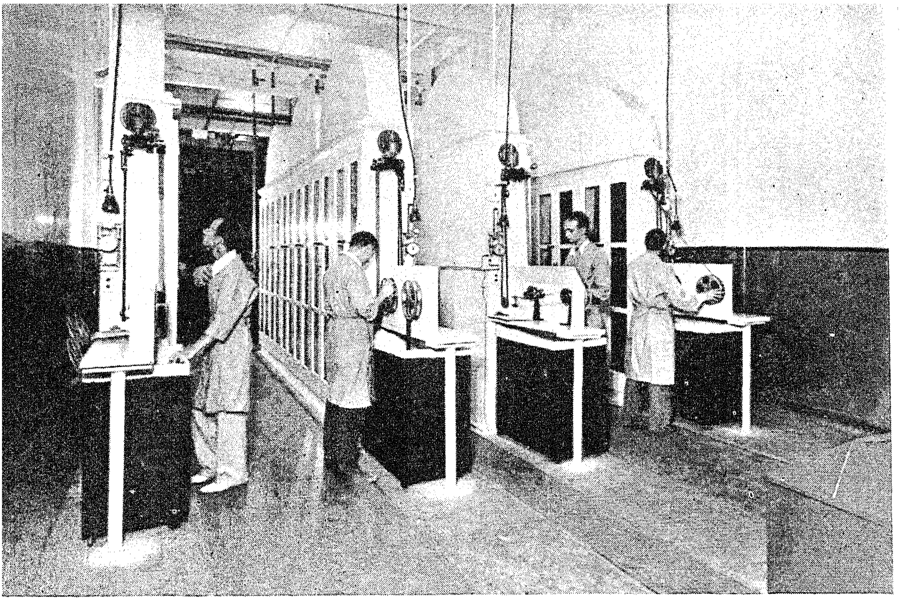
processed under the conditions which will hold for that day's production. Meanwhile, on the stage itself the position to be occupied by the 'mike' on its long boom is decided, bearing in mind the positions on the set of the actors, and that shadows from the boom or mike must not fall within the picture area. At the side of the stage is a glass-fronted box in which sits the man responsible for controlling the amplitude of the recorded sound-track.

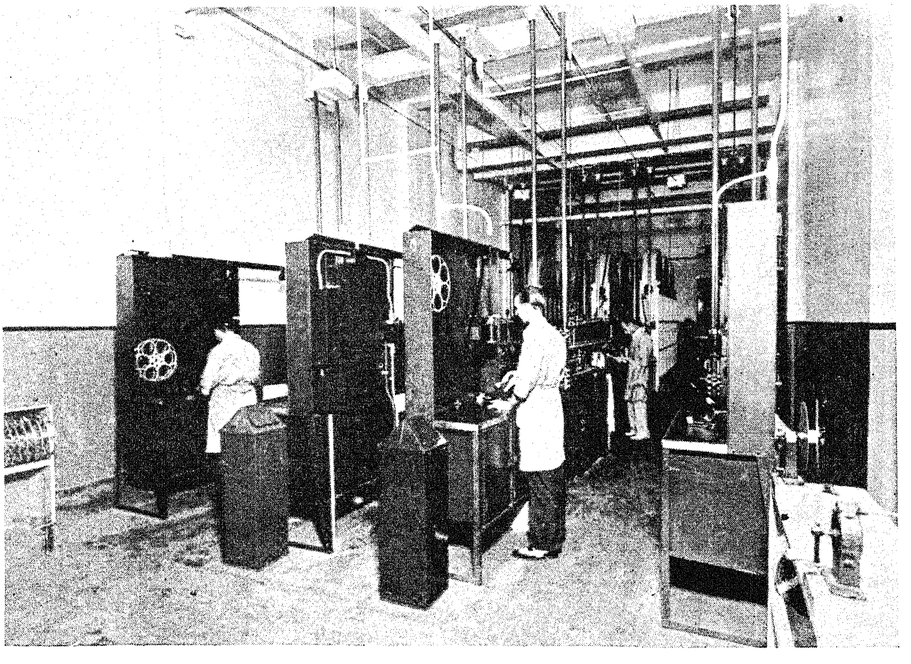
Before shooting can commence a large number of preliminaries must be properly co-ordinated. In a typical example, signals must be given to carpenters working on nearby sets to stop hammering. Extraction fans ventilating the studio must be stopped, the doors must be locked, and a general warning given that shooting is to commence. Then the lights must be switched on, the sound camera started to allow it to get up to the right running speed when recording commences, the actors warned, the picture camera started, and then the director gives the word to shoot.

A slip at any one of these points may cost anything from five to fifty pounds in wasted time and material, and accordingly present tendencies are to co-ordinate individuals and apparatus by putting the control of all production machines and signals into the hands of a single operator situated at a switchboard. In one studio, by pressing a single button on this board every one of the operations listed above is thereafter performed automatically and in proper sequence, so that not a scrap of film is wasted and not a single vital point overlooked when the director gives the word. Actually the operations are divided into three groups. The first pressure of the button brings the set to the 'ready', i.e. it shuts down the ventilating plant, switches on all warning signal lights, locks the studio doors, and either switches on the set lights or else signals for them to be switched on. A second pressure on the same button switches on the sound-recording camera, and a pause follows to enable this camera to get up to a steady speed, whereupon the picture cameras start up. Thereupon



Above. A Studio Camera on a Dolly
Below. A Studio Camera on a Crane
Photos by courtesy of Messrs. W. Vinten, Ltd., and Ealing Studios





In a Modern Motion Picture Processing Laboratory

Photos by courtesy of Metro-Goldwyn Mayer

the marker light records its synchronizing guide on the film edge, and a buzzer tells the artists that the shot has commenced. A third press of the same button will switch off cameras, recorder, marker lights, set lights, warning lights, locks, give an 'all-clear' ring on a bell, start up the ventilating plant, and finally return the robot controls back to the starting-point ready for the next take.

The work of so many specialists and the performance of so many contrivances and instruments are involved in the making of a film that the director's task of adjusting and harmonizing them is an impressive one. To get the best out of each unit is the director's real test. He must envisage the production as a whole since with him lies the decision as to the extent to which sound quality, for example, must be sacrificed for photographic quality. Such decisions must often be made on the studio floor, and the director must have sufficient mental agility to reshape his plans without sacrificing any of the production value. In so far as he is not capable of this task, production costs will rise and hit-or-miss shooting will result. His watchdog is the lynx-eyed continuity clerk, whose duty it is to make mental and written notes of every point in the scene and its action which must be borne in mind when shooting its successors (and perhaps predecessors, see p. 60). Every detail of the clothes the actors are wearing, the positions they are occupying as they speak the first and last lines in the scene, and so on, must all be available for future reference. The scenes themselves are usually quite short, very few taking longer than a minute or so to shoot, but each scene may be shot a number of times before the director is satisfied that the effect he wants is 'in the can'.

As each scene is shot and processed it passes to the editor's hands. The picture and sound-track are played over in synchrony on an editing machine, and a decision made as to how much of each shot is to be retained. At this stage also it frequently happens that re-recording of the sound-track is found to be desirable.

Thus, two shots which, in the completed film, will appear consecutively may in fact have been photographed with an interval of several weeks, and the sound may have been recorded at different levels. At this point also the desirability of introducing a background of music or other sound effects will become obvious. In such cases two or three additional sound-tracks can be superimposed on the original track by reproducing each track separately and re-recording the composite sound which results. This procedure is nearly always followed in making 'musicals'.

Pre-scoring

Songs and orchestras are only rarely recorded during the actual filming of the picture. Instead they are recorded in advance (or pre-scored) on a special stage built for music recording. On this stage microphones can be placed to the best advantage because they will not appear in the final picture. Moreover, the singer and the orchestral accompaniment will probably be recorded on different occasions. First the orchestra plays the accompaniment, the soloist mouthing the words silently while the conductor, watching her mouth, directs the orchestra accordingly. The orchestra is then dismissed, and the record of the accompaniment is played over at a fairly low level so that the soloist can hear clearly every note she sings without its being drowned by the orchestra. Probably the soloist sings over the song two or three times, pulling all the peculiar faces she may find necessary in order to produce her voice at its best, for only a sound record of her performance is being made. The best sections of the records she has made are now assembled together into a combined record with the orchestral accompaniment, and this combination is played back during the photography of the scene in which the soloist and orchestra appear. During photography the soloist listens to this playback, but now she need not worry about the quality of her singing and can concentrate on looking her best

as she follows with her lips the words she sang on the previous occasion.

Film Editing

From the mass of film shot on the studio floor the film editor or cutter must select the shots that will make up the finished film. When it is remembered that perhaps less than one-tenth of the footage which has been exposed will be used for making the final film, it becomes obvious that the editor can make or mar a film. On the one hand he can completely destroy the atmosphere for which the director has been striving, and on the other he may be able to sort out from masses of 'hit-or-miss' material handed over to him by a poor director a series of sequences which he so cuts that a first-class film is nevertheless obtained. Frequently he can create situations in a picture that make for its success and yet were not visualized as such during its filming.

The best results are naturally obtained when the director and the editor work in close harmony and are open-minded to suggestions. Incidentally, British films could probably be made a commercial proposition if directors did more of the cutting on the studio floor. To shoot 100,000 feet of film in order to obtain a 7,000-foot film is practical politics in America, which has a world market for its films. It must be remembered, however, that 90,000 feet of unused negative involves a good deal more than the mere cost of the stock. Exposing it involves overheads in salaries, rents, and studio expenses generally which must be covered before the film can make profits. The spirit of the apocryphal Chinaman, who, finding that a dead pig in the ashes of his house tasted good, continued to set fire to houses containing pigs whenever he wanted roast pork, has been abroad so long in the film industry that his methods have become second nature. On the other hand, although 'overshooting' a picture is an expensive luxury which the British industry cannot

afford, even though it may not realize the fact, it is of course the safest way of proceeding. The director who tries to cut the picture in the camera must be very sure of himself and the effect he wants to produce; but an economical director, by allowing sufficient overlap in the dialogue and action while shooting his scenes simultaneously from various angles, will save his company thousands of pounds. Above all, preparation is the keynote of the financially successful picture, and, in consequence, the best directors have nearly all risen from the ranks of editors.

As a rule cutting begins on the completion of each sequence, the editor selecting those shots that seem to him to present the sequence in the most effective manner. This procedure continues as the director shoots the picture, so that a few days after the shooting is completed the film is ready to be viewed in its first or 'rough cut' stage. The 'rough cut' version will probably be too long and further editing will take place in consultation with the director and producer. It may be that some scenes and situations have 'misfired' and that others could be improved by the substitution of some of the rejected material for that actually selected by the cutter.

Sound effects and background music are added at this point as well as the various trick effects, dissolves, wipes, and so on made in the optical printer (p. 137), and the film is ready for the 'preview'. Here, the film is 'tried on the dog'—that is, the reaction of a typical audience is obtained by showing it in a theatre. Scenes that misfire will be shortened or eliminated, and thereupon, providing that it has also passed the censor, the film is at last in its final form.

As soon as the chosen negative material has been edited a single positive print is made from it and the original irreplaceable negative is locked away in a safe place. From the positive print, which is usually referred to as a 'lavender' because, for photographic reasons, it is made on lavender-coloured stock, duplicate negatives are prepared, and from these the release positives are

printed. Naturally, the photographic and sound quality inevitably deteriorates slightly at each printing process, and first-class technique is essential if quality approaching that of the parent positive print is to be obtained in the release print.

CHAPTER V

MANUFACTURE AND PROCESSING OF CINE-FILM

STANDARD motion-picture film support is chiefly made of celluloid—cellulose nitrate. The cellulose nitrate is dissolved in suitable organic solvents, and the resulting dope is fed in a uniformly thin layer on to an endless band of polished metal—usually silver- or chromium-plated. The conditions are so arranged that in a very short time the solvents have evaporated sufficiently to enable the skin of celluloid to be peeled from the surface of the moving band in the form of a tough transparent layer, which is led through a series of drying chambers where the remaining solvents are removed. Approximately 90 per cent. of these solvents are recovered from the air in which the film is dried.

In this way lengths of film support usually about 2,000 feet long and perhaps 2 feet wide are obtained. The material so produced must conform to rigid specifications as regards its mechanical strength, flexibility, and shrinkage characteristics. In all these respects it is considerably easier to produce a satisfactory material from celluloid than from cellulose acetate, and although, therefore, the non-inflammable acetate is universally used for amateur sub-standard film, professional film, which has to withstand much harder wear and in which 'jerkiness' of the projected picture due to shrinkage of the film support would be much more noticeable, is nearly always celluloid.

In order that the gelatine emulsion shall adhere properly to the celluloid, the surface of the latter is next coated with a thin layer of a solution which has chemical and physical properties intermediate between those of celluloid and gelatine, this substratum, as it is called, amalgamating equally well with the film support and the emulsion layer and cementing the two together.

The film base, with its substratum coating on one side and possibly a layer of anti-halation or tinting

dyestuff on the other, is now ready to be coated with the light-sensitive emulsion. The general characteristics of such emulsions have been described in *Photography To-day* and need not now detain us. Although the making of a photographic emulsion of sorts is a fairly easy matter, the production of modern highly sensitive, fine-grain, clean working emulsions suitable for cinematography is an exceedingly intricate problem, and each manufacturer guards carefully the recipes he has evolved. The factors which control the characteristics of an emulsion are so numerous, and at the same time so interdependent, that it is safe to say that no two batches of emulsion have ever been identical in all respects, while the problem of satisfying the photographer's demands for maximum speed, minimum grain size, optimum contrast and colour sensitivity, and gradation grows daily more formidable. Nevertheless, the improvement in photographic emulsions which the stimulus of cinematography has brought about in recent years is startling, and photographic quality which was deemed first-class when sound-films were introduced would not now be tolerated.

Several different types of emulsion are required. Thus the film used in the camera must be as sensitive to light as is consistent with other desirable qualities. Moreover, it must be rendered sensitive to all wavelengths of visible light in order that it may record correctly the colour values of the subject. The silver bromide which forms the basis of photographic emulsions is only sensitive to blue light, and the red, yellow, and green rays reflected from coloured objects have very little effect upon it. Accordingly, minute quantities of sensitizing dyestuffs are added to the emulsion. These dyestuffs are adsorbed on to the surface of the silver halide grains, forming a light-sensitive skin which transmits to the grains the energy of the rays which it has itself absorbed. Moreover, by a suitable choice of sensitizing dyes, it is possible to render the emulsion preferentially sensitive to any chosen region of the spectrum, such emulsions being of value in colour

cinematography and in obtaining some of the special effects described in Chapter IX. The positive film used in the projector is, however, printed from a monochrome negative. Colour sensitivity is not, therefore, required, and, indeed, the overall sensitivity to light can be relatively low, but fineness of grain becomes of paramount importance.

Whereas twenty years ago there were only two types of cine-film—negative stock for use in the camera and positive stock for making prints—to-day there are over seventy different varieties, thirty of which are of the safety base (non-inflammable) type. These varieties can be classified broadly as follows:

1. *Negative Stock.* Nowadays this is nearly always panchromatic, i.e. more or less sensitive to all wavelengths of visible light, of the fastest attainable working speed consistent with an acceptable maximum grain size. (Speed and grain size are to a considerable extent interdependent in the sense that the greater the working speed the greater the granularity.) The film has a long scale of gradation and usually has some form of antihalation backing.

2 *Positive Stock.* This is non-colour sensitized, of low speed (somewhat faster than bromide paper), of steep scale of gradation (high contrast), and very fine grained.

3. *Sound-recording Stock.* Various types are employed by the different systems ranging from low speed, fine-grain material, to film whose speed is as high as is consistent with obtaining a reasonably dense image. Sound-recording stock designed for use with ultraviolet light is stained yellow to limit the action of this light to the surface layers of the emulsion.

4. *Reversal Stock.* This is usually a safety base film in which the camera-exposed image is chemically reversed to a positive for projection. During the first, or negative, exposure the larger, more light-sensitive grains are chiefly affected. These are then bleached away during processing, and the unexposed, slower and smaller grains are blackened to form the positive image (see

p. 79). Reversal stock is mainly of interest to the amateur cinematographer. Amateur systems of colour cinematography, for example, are all reversal processes.

In coating the emulsion on the film support, elaborate precautions are taken to exclude dust and dirt. Absence of dust is, of course, very desirable in photographic emulsions intended for ordinary photography since, even when the particles themselves are invisibly small, they may result in visible white or black spots as a result of local sensitization or desensitization of the surrounding emulsion. When, as in the cinema, such spots are magnified some hundreds of times, their presence becomes intolerable, for we not only see them, but when they fall on the sound-track we hear them as crackles from the loud speaker. Accordingly, in designing the coating room of a film factory the problem of keeping out dust hardly takes second place to that of keeping out light. It goes without saying that only washed and filtered air ever reaches the coating room, but that is not sufficient. Every item used in the room's construction, every piece of plant and the special clothes which the employees wear, is planned to defeat the enemy—dust.

The sensitive emulsion is picked up from a coating roller by kiss contact with the travelling film, which then passes into a chilling box where the emulsion sets to a jelly. The film then passes into festoons which travel slowly up a drying tunnel, whose temperature and humidity are varied from point to point to ensure that the water shall be removed in a predetermined manner, for even the way in which the film is dried has an important influence on its photographic characteristics.

The dried film is slit into strips 35 mm. wide, and then passed through perforating machines which punch out the sprocket holes. Slitting is done by revolving razor-edged knives equally spaced above and below the film. The film must be perforated with extreme accuracy, and the punches and dies are so accurately made that the punches cannot be inserted

into the dies by hand without injuring them, although when clamped in the machines they will go in and out thousands of times without appreciable wear. Each punch consists of eight punching members and eight positioning members or pilots, four on each side of the film. As the film passes through the punch four pairs of holes are made. A shuttle then moves the film four spaces forward, and four pilot pins enter the perforations and position the film before the punches strike the new holes.

At last the material is recognizable as motion-picture film, but a further period of conditioning and testing elapses before it passes to the customer. The scrupulous care which is taken at every stage in the manufacture of the film is such that this final testing rarely reveals the slightest flaw, and 99 per cent. of the final testing would in any other photographic product be considered unnecessary; but the motion-picture industry is one of the most critical markets for sensitive material, and it is certainly the best catered for.

Processing

After the film has been exposed in the cine-camera it is sent to the processing laboratory for development and printing. There are about twenty such laboratories in England, a few of which are operated as independent companies. Usually, however, the laboratory forms a part of the production centre since, apart from the advantage of close co-operation between cameraman and processing unit, this enables 'rush' prints of the day's shooting to be available for inspection by the director and producer within a few hours of the actual filming.

In the early days of the cinema, film to be developed was wound on to racks rather like clothes-horses and developed in tanks, the time of development being left to the discretion of the darkroom operator, who would withdraw the rack occasionally for inspection. Apart from the fact that little is to be gained by such procedure —for errors in exposure could not be compensated for to

any useful extent by variations in development time—the coming of sound-film made trial-and-error development impracticable, and standardized systems of development in which the film passes continuously through tanks or long cylinders containing the various processing solutions are practically universal.

Apart from the gain in output (and some modern laboratories process millions of feet of film every week, using developing units with outputs of up to 200 feet per minute), the standardization of development procedure guarantees uniformity of sound and picture quality. The cameraman must accordingly make any alterations to the key of the scenes he photographs by modifications to the studio lighting and the exposure. This is, of course, the logical way of making such alterations since it places the effects obtained under the direct control of the man who is best able to visualize them and whose responsibility it is to obtain them.

In a typical processing plant the film to be developed is spliced on to a leader strip of film which draws it through a series of tanks containing developer, rinsing water, fixing bath, and washing water. Thence the film travels through a drying cabinet, at the far end of which it is spooled up ready for transferring to the printer. In some plants the tanks consist of long tubes containing the processing solutions, the film travelling down the tube, round a weighted diabolo, and up again. The rate at which the film travels is constant, and the time of immersion in each tube can be altered by altering the length of the loop. In another type, large tanks are used, the film travelling up and down the solutions in a series of loops each kept to its proper length by a weighted diabolo, and to its proper position in the series by passage over sprocket wheels travelling on a driving rod which crosses the tank. In some plants rinsing and washing is done by directing water sprays directly on to the film as it hangs suspended in the tanks. As the film leaves each tank it passes between suction or blowing nozzles which remove the surface liquid.

In order that the activity of the developing and fixing

solutions shall remain constant they are continually replenished, the replenishing solutions containing the appropriate chemicals in amounts proportional to the rate at which each is used up during processing. Gradually, however, the developer becomes charged with soluble bromide derived from the film emulsion, and in order that this shall not restrain development, its concentration is kept within the necessary limits by omitting bromide from the replenisher and by rejecting an appropriate portion of the used solution at each replenishment. The fixing bath, which becomes charged with silver salts, is in some laboratories passed to a silver-recovery plant. Here an electric current is passed through the used solution, whereupon the silver in solution is electroplated on to the anode and recovered for refining, while the sodium thiosulphate—the chemical responsible for fixation—is regenerated. The silver-free solution can accordingly be returned to the film-processing plant. It is interesting to note that when this system was finally perfected the price of silver was so low that it would not have been worth while to install the recovery plant merely for the sake of the silver. On the other hand, such enormous quantities of thiosulphate are required annually by the motion-picture industry that the possibility of using one charge almost indefinitely was in itself a sufficient inducement to adopt the system.

When the camera-exposed film has been developed the images on it are negatives, for wherever light has fallen on the film a black silver deposit is obtained and the record of light and shade of the subject photographed is, therefore, inverted. In order to obtain images in which the relationship of the light and shade corresponds with that of nature, the negative is printed on to a second film, when a second inversion takes place and a 'positive' record is obtained. To make such prints, the negative film is brought into contact with a suitable type of positive film, and the two films, face to face, are drawn simultaneously past a light source. In some printing machines the films move continuously

past a narrow illuminated slit. In others the picture is printed frame by frame, the films being drawn into a gate where exposure takes place by mechanism similar to that employed in the camera. The sound-record cannot be printed successfully on intermittent printers of this type, however, and a further attachment is necessary for continuously printing the sound-track.

A finished film is made up of many hundreds of separate scenes, some of which last only a second or so. These scenes have often been exposed under very varying lighting conditions, and, in order that the brightness of the picture as seen on the cinema screen shall not be constantly jumping up and down with the changes of scene, it is necessary to vary the exposure during printing to compensate for the varying overall density of the negative film. This variation is usually accomplished by cutting notches in the leading edge of each scene in the negative. These notches engage in teeth in the printer mechanism, and so operate devices which vary either the area or the brightness of the printing light. In other printers metal studs are inserted in sprocket holes on the negative, and these make electrical contacts at the appropriate points, the number of contacts made at the beginning of each scene or the distance between them being used to control the amount of exposure the film which follows is to receive. The grading of the negative scenes is usually done by visual inspection. Film rushes through a modern printer at anything up to 100 feet a minute, and usually passes directly to a processing unit of the type already described in which it is developed, fixed, washed, dried, and then perhaps waxed along the edges to lubricate its passage through the cinema projector.

Sub-standard Film

Even if they were presented with the equipment, few private people could afford to indulge in 35-mm. cinematography as a hobby. By the time their pictures were projected on the screen they would have cost something like £1 per minute in film alone! On the other hand,

the amateur does not require to project a picture 20 feet wide, nor does he usually require more than one positive of each film. Accordingly, a lower running cost is made possible in the sub-standard film due not only to its smaller size, but also to the use of the so-called 'reversal' system of processing. In this system, instead of developing the film exposed in the camera to a negative which must be printed on to a separate film, it is converted directly into a positive. The usual method of accomplishing this is to develop the exposed negative image, and then, instead of fixing out the unexposed silver halides as in the normal negative-positive system, the exposed metallic silver is dissolved out by treating it with a suitable oxidizing bath. The undeveloped silver bromide which remains in the film is now exposed to light and treated with developer, giving the positive image.

The stages in this process are shown in diagrammatic form in Fig. 21, which shows the same area on a film after each operation.

In the form described the reversal process will only give a satisfactory positive over a small range of exposures, since, if the original exposure in the camera is too short, the negative image which is obtained on the first development, although perhaps quite satisfactory as a negative exposure for printing from by the negative-positive system, will leave on bleaching an excessive amount of silver halide and the final image will be too dark; while if the camera exposure was too long, there will not be sufficient silver halide left after bleaching to give a dark enough positive. The results, in fact, could scarcely be more satisfactory than those which would be obtained in ordinary photography if we printed all the varied types of negative, which even the most careful technique produces, on one grade of paper using one fixed exposure. There are several methods available for compensating for this defect in the simple reversal process, but as they consist for the most part in modifying the final stages of processing after examining the nature of the first developed image, they are of greater

value to those who use the process for mosaic screen colour photography than to makers of cine-films, since it is not convenient to inspect and then give special treatment to individual shots, of which there may be twenty or so in one reel of film.

There is, however, an ingenious system invented by the Kodak Company which automatically compensates each individual shot for all but the grossest errors in exposure.

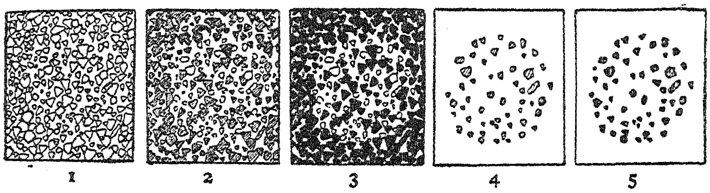


FIG 21. Reproduction of a Grey Dot or Point by the Reversal Process.

1. Unexposed emulsion. 2. Exposed emulsion. The light-struck grains are indicated by shading. 3. First development. The light-struck grains have been converted to black silver, giving a negative image. 4. The developed silver grains have been dissolved away and the remaining grains exposed to light. 5. The grains fogged by this second exposure are developed to form the final positive image.

In this controlled reversal system the film, having been developed to a negative and had its silver image bleached away, passes between a source of infra-red rays and a photo-electric cell. The amount of silver bromide left in each frame controls the amount of infra-red light falling on the cell, and the electric currents produced by the cell under the stimulus of these rays operate a galvanometer vane which, as it moves aside in response to the currents received from the cell, permits light to fall on the film, the amount of this exposing light being thus proportional to the amount of infra-red transmitted by the film. If there is a lot of silver bromide left in any particular shot, it is taken as a sign that the film was under-exposed; very little infra-red passes through the frame, and, therefore, very little light is permitted to reach the film during the second exposure, and vice versa. In this way, each frame receives just

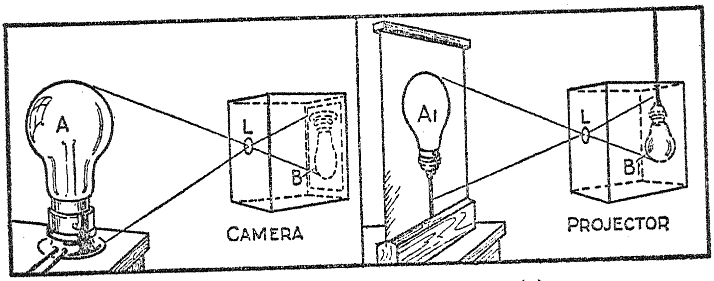
that exposure necessary to render the right amount of silver halide developable, and after this second development any unwanted silver halide is removed by fixation. Of course, this system necessarily treats each frame as though it were an 'average' subject; and if, for example, a shot is taken in which a large proportion of each picture would properly be rendered as very dark indeed, e.g. a close-up of a blackboard with a title on it, the automatic controlled reversal process would, on finding a large amount of silver halide left in the frame, proceed to treat it as though it were under-exposed, and the result would be greyer than is desirable. Such exceptional shots can, however, easily be intensified individually, and then spliced back into the film.

Most manufacturers process sub-standard film on continuously running machines consisting of a series of tanks which carry racks with rollers, by means of which the film is fed continuously through the solutions. The machines are entirely automatic, the films being fed in as they come from the customer and taken out of the drying chamber as positives ready for projection. In little more than an hour from the time the film enters the machine it is ready for projection, and each machine takes a new film every five minutes.

CHAPTER VI

THE PROJECTOR

A PROJECTOR may be loosely defined as a camera turned inside out. Projection, that is to say, makes use of the fact that the formation inside the camera of a picture of things outside it, is a reversible process. To take the simplest imaginable instance: Fig. 22 (A) shows a photographic set-up in which the image of a large electric



(A) FIG. 22. (B)

lamp *A* is being thrown on to a sensitive plate *B* by a lens *L*. If, as in Fig. 22 (B), we substituted a real lamp *B*1 for the image on the plate, then we could get a large image-lamp *A*1 by simply standing a screen where the real lamp originally stood.

In actual practice the elements involved are a little more complicated. The objects which we photograph, and the pictures which we project, are not usually self-luminous. They are lit up by a separate source of light. But this does not affect the simple fundamental principle illustrated in Fig. 22. In fact, this principle once dominated the design of cinema apparatus, for the majority of early equipments were of the camera-projector type convertible from camera to projector by the attachment of a lamp and condenser. The three instruments only drew apart in design as the essential requirements of each came to be more clearly understood.

The weakness of the converted-camera projector

which first claimed attention was the painful flicker-effect which it produced. This trouble had not been foreseen by the pioneer designers, and proved difficult to overcome, as the power to distinguish between light and darkness is a very deep-rooted one, existing even in the most rudimentary forms of life, and is proportionately difficult to thwart.

At first the line of argument followed was that to be aware of flicker is to be aware of the dark phases, and that flicker could be done away with by making these dark phases shorter. To accomplish this, the speed of picture shift was drastically increased, regardless of the stresses thus imposed on the film perforations. The flicker effect, however, persistently refused to yield to this treatment, and finally the paradoxical solution was reached that, in order to avoid being aware of any dark phases, it was necessary to add more dark phases to those already necessitated by the shuttering-off of the light during the picture shift. If extra dark periods were added to the alternations of dark and light caused by the rotating shutter, then the flicker effect vanished as though by magic. The effect required was, from the mechanical point of view, easily enough accomplished by adding an extra blade, or even two extra blades, to the rotating shutter. These extra blades wasted, and have ever since continued to waste, about a fifth of the light which would otherwise help to form the picture on the screen, but though many proposals have been made for eliminating flicker by other means, this seemingly somewhat crude method still remains the only one which is practical.

The blades into which the shutter is divided must be of equal size and equally spaced. In consequence the addition of extra blades made it essential to devise a more rapid picture shift, adapted to narrower blades. Claw movements, such as the camera uses, were, however, too harsh on the film when they functioned at such high speeds. A negative, it must be remembered, passes through the camera once only, but a positive must be projected many times, and this consideration makes the

projector designer keep an anxious eye on the problem of film wear. Claw movements are not on the whole kind to film. A projector manufacturer, in advertising an instrument making use of an alternative type of movement, announced recently that the dictionary definition of a claw was 'an instrument designed to tear or rend'. This definition perhaps rather overshoots the mark in the present context, but, except in amateur apparatus, which will be dealt with separately in Chapter X, the claw movement has proved unsuitable for projection purposes. The movement employed in almost all professional projectors is the four-armed Maltese cross. The Maltese cross is a form of gearing in which the driven wheel (the cross), instead of being rotated continuously by the driving wheel, is rotated in a series of jerks separated by stationary phases.

A four-armed cross will go round in a series of four jerks to each complete rotation, so that if a toothed wheel with a circumference equal to the height of four pictures is actuated by the cross, it will cause the film to travel exactly one picture-height at each jerk.

Fig. 23 shows the elements of the device in diagram. The advantages of this type of device are twofold. In the first place, the film is neither started off by a tug at full speed nor stopped by a sudden jolt at full speed. Perhaps therefore 'jerk' is hardly a fair description of the film's movement.

It is in the nature of a gear of this kind to start its moving phase at a low speed, rapidly gain high acceleration, and then lose speed again before the stationary phase. This is a desirable characteristic in intermittent movement if wear and tear are to be avoided, as those motorists discover whose idea of starting and stopping is to start by accelerating the engine and letting the clutch in with a jerk, and to stop by jamming both brakes full on while the car is still travelling at high speed.

A glance at Fig. 23 will show that as the driving pin runs down into each slot and exerts its pressure progressively nearer the centre of the cross, the effect is as though the driven wheel kept decreasing in size, so that

it is driven faster and faster by the driving wheel. This effect is reversed when the pin begins to draw out of the slot again, the drive becoming slower and slower until the locking cam of the driving wheel finally fits itself against the hollow edges of the cross and holds it motionless.

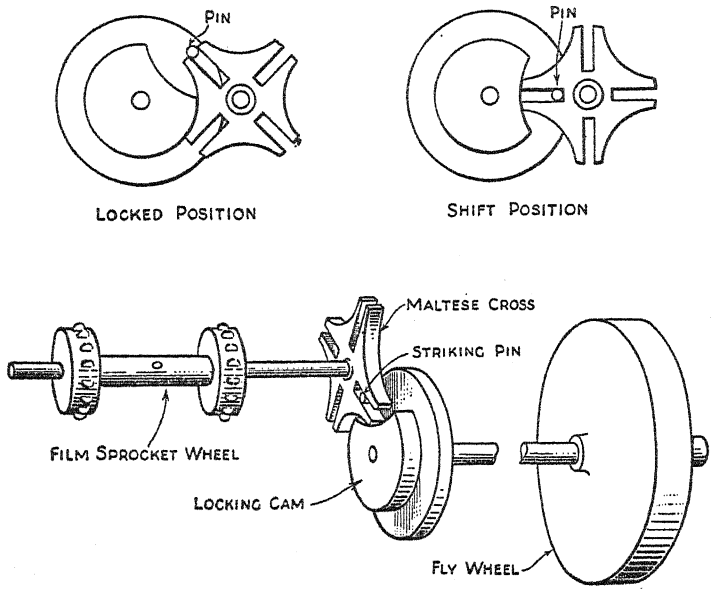


FIG. 23. Maltese Cross Mechanism.

The second advantage of an intermittent sprocket movement, as compared with a claw movement, is that the teeth of the sprocket wheel are in constant engagement with the perforations of the film, whereas the claw, poking forward, has to effect a fresh entry for each picture-shift and cannot avoid inflicting damage if it fails to find the perforation exactly in position at the crucial moment. The cross movement is, as it were, the heart of the projector mechanism, and the steadiness of the picture on the screen depends almost entirely on the precision of its manufacture.

The component parts are consequently ground to an accuracy of within 1/10,000th of an inch. However

accurate the projector parts, the picture would, of course, be unsteady if the whole installation were to vibrate, and a substantial cast-iron base is essential.

A well-projected picture is not only steady, but is bright and critically sharp.

The brightness of the picture will depend on the combined efficiency of the lamp, its condensing system, the shutter, and the projection lens. The picture's definition will depend chiefly on the quality of the projection lens.

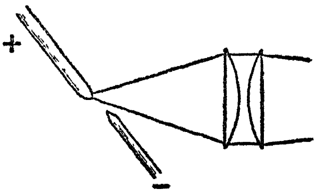


FIG 24.

The lamp used for projection in picture theatres is invariably an arc-lamp, that is to say, a lamp made by causing a current to jump an air-space between the ends of two carbon rods. When this occurs the rod which forms the positive terminal of the spark-gap rapidly develops a small crater of white-hot carbon.

Arc lamps were the first type of electric lamp to be turned to practical account as illuminants, and the early designers of projection apparatus may be accounted lucky to have had at their disposal a type of light source so closely approximating the ideal for their purpose, in that it produced very intense light from a small incandescent area.

The arc in the lamp-house of a modern projector is, however, a much improved version of the early arc-lamp.

Fig. 24 shows the manner in which the carbons were set in an early type of arc and the type of condensing system used. It will be noticed that the lower carbon (the negative one) is the smaller of the two. This is because it would otherwise get in the way of the light emitted from the crater of the top carbon, which is the active member of the pair. A coating of copper gives the negative carbon the necessary current-carrying capacity in spite of its small diameter. The large carbon is made with a soft core so that its crater may not tend to wander from a central position.

The condensing system is a pair of lenses placed between the arc and the film gate.

About the year 1920 improvements in the manufacture of heat-resisting mirrors made it possible to substitute a mirror behind the arc for the lenses in front (Fig. 25).

The carbons were now placed horizontally, the negative passing through a central hole in the mirror. As the glass lenses had inevitably either absorbed or reflected in the wrong direction a large proportion of the light from the arc, the new arrangement was considerably more efficient. This condensing system is still in general use with some minor modifications.

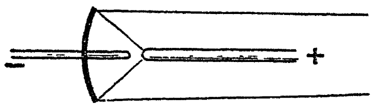


FIG. 25.

A further extension of the arc's powers came with the discovery that certain metallic salts when incorporated in the core of the positive carbon raised its light output to a yet higher level. This discovery, however, brought new problems in its train, for the increased light was found to come from the incandescent gases, which naturally flicker about unsteadily, rather than from the crater. This trouble has been met in some designs by contriving that the crater shall be of great depth, in which case the gases are held partially imprisoned by the crater walls, and in others by incorporating electromagnets which can exercise a guiding control on the flames owing to the fact that the incandescent gases are conducting current.

Since the functions and design of the positive and negative carbons are so different it might be imagined that alternating currents which keep rapidly reversing the polarity of the terminals would be nearly useless for feeding an arc. Until recently this was believed to be the case, and the alternating current supplied by the mains was accordingly rectified. Now, however, an alternating-current arc is available for theatres of moderate size which makes use of the discovery that an alternating arc will work efficiently when its voltage is kept low (25

volts would be a typical figure) in relation to its amperage.

Arcs of every type emit an intensely hot beam, capable of firing the film almost instantaneously if it played on it while standing still. Accordingly the beam is intercepted by a safety shutter which lifts only when a certain speed has been reached by the mechanism.

Moreover, the rotating shutter is now invariably placed behind the film in order that it may shield the film from the arc except during the actual instants when the picture is being projected on the screen. Formerly the shutter was generally placed in front of the gate, which would be the most efficient position if optical considerations alone were in view. Additional protection against fire on a large scale, should the film catch in the gate, is given by the metal housings for the spools.

The natural construction and scale of a modern picture theatre results in long distances between the projector and the screen, and in consequence if the projection lenses are to throw an image of suitable size on the screen they must have focal lengths which, were they camera lenses, would put them in the telephoto class. In these circumstances the designer finds it difficult to avoid the arc beam reaching its most compressed point before it gets to the lens and spreading again to a diameter too large for the back glass of the lens. The lens designer seeks to counteract this tendency not only by conferring as large a diameter as possible on the back glass of the lens, but also by planning that it shall protrude backwards as far as is compatible with the required focal length of the whole lens combination.

The projectors which produce the pictures in picture theatres, being stationary instruments with a fixed job to perform, lack the varieties of functioning and consequently of design which we noticed in cameras.

Cameras, it will be recalled, are equipped with a battery of lenses of different focal length. Projectors are required to produce pictures of a given size from a given point and therefore need only one lens. It is true that experiments were tried some years ago in equipping

projectors with lenses whose focal length could be altered at will while the projector ran, and thus cause the picture on the screen to expand or contract. On the first occasion on which the idea was put into practice the effect aimed at was that of vividness, when a herd of wild elephants charged towards the audience and the screen expanded as they approached—or seemed to approach—the sevenpenny seats in the front row. It was agreed at the time that a very genuine thrill had been produced, but, wisely perhaps, no attempt was made to bring the variable-focus projection lens into general theatrical use.

Cameras are also designed with various ranges of speed, but the projector is tied to one exact speed both by the requirements of its sound track and by other considerations such as flicker and film wear.

One theatre projector, therefore, hardly differs from another except in the power of its arc, which must be sufficient for the size of picture to be produced.

There are, it is true, a few types of projector designed for showing full-sized films elsewhere than in picture theatres. These frequently use filament lamps instead of arcs. There is, however, a growing tendency to use substandard film (i.e. film of width less than 35 mm.) for all displays outside the theatres; the design of substandard projectors is reserved for description in a later chapter.

From time to time projectors have been designed, and even marketed, that make use of various optical compensation devices in order to avoid the necessity for an intermittent movement which must necessarily impose a certain amount of wear and tear on the film. It will be recalled that devices of this nature were described in Chapter II in connexion with high-speed cameras. These were instances where the speed of the film reached a point at which film wear became the primary problem. At normal projection speed, however, film is capable of standing up to intermittent motion without undue strain, and in consequence optical compensation projectors have never found favour.

They may, however, be useful in special circumstances. For example, a projector of this type is in use for transmission of films by television from Alexandra Palace.

Radical changes in projector design do not at the moment seem imminent. The substitution of high-pressure mercury vapour lamps for carbon arcs is already within the realm of practicability, but it will merely reduce the bulk of projectors and affect their appearance without introducing any new features apparent to the man in the auditorium.

CHAPTER VII

THE PICTURE THEATRE

A WALK along the main streets of any city, town, or even large village emphasizes as nothing else can the important part played by the film in modern life. The picture theatres out-top the other buildings by day and outshine them by night.

That they should do so is not surprising, seeing that the cost of their construction is often over £300,000. In fact, it is estimated that the capital value of the cinemas at present in use in Great Britain exceeds £90,000,000.

When the archaeologists of A.D. 2039 dig up the ruins of this civilization they will perhaps be surprised at the colossal fragments which will bear witness to our devotion to the great task of keeping ourselves entertained. Or perhaps our largest super cinema will seem to them a very humble anticipation of the post-sup cinema of their own more sophisticated age.

In the early days of cinematography the isolated displays given by this new invention were, of course, items in the programme of existing places of entertainment. Soon there arose a demand for continuous displays of moving pictures, and empty shops were converted for the purpose. Fig. 26 shows an ingenious conversion of a shop front. The insertion of a glass pane on the first-floor level gives every one in the street a good view of the inside of the operating-box.

The next step came when audiences outgrew the capacity of converted shops, and exhibitors found themselves in a position to make full use of large assembly halls. As early as 1913 the Hippodrome in Paris claimed to 'cater for over 5,000 cinema enthusiasts daily'. It is to be presumed, however, that the figure represents a total of patrons during one day, rather than the seating capacity for a single audience.

Many years elapsed, however, before the external design of the buildings began to reflect the practical needs of a picture theatre.

The upper picture in Plate 9 is described in 'the showman's advertising book' (1914) as 'an ideal outside display'. Yet to our eyes it looks as if it needed the attentions of a giant with a broom who should clear

FIG. 26. Converted Shop Front.

away the lettering tacked on to the classical columns and sweep the approach free from its litter of upright poster-boards.

The modern exterior shown in the same Plate may have its faults, but at any rate all the items of outside publicity have a place where they belong. It has a flat strip above its portico specially designed for moderate-sized lettering, while blank rectangular spaces have been left in the main façade and side walls for displays of bolder dimensions. Secondly, a number of small spaces have been left round the entrance at eye-level, to which frames

holding posters are attached. This certainly seems preferable to the cluster of boards which stand on the ground in front of the old-fashioned cinema, waiting to be soaked by a shower or blown over by a gust of wind. Thirdly, the flat canopy which protrudes above the entry and along the sides of the modern building is clearly going to provide very welcome shelter to waiting queues.

To enlarge on the general appearance of a modern picture theatre would be to insult the powers of observation possessed by the reader, and we shall accordingly concentrate attention on those points of good design in a cinema which are not self-evident and on those parts of a cinema to which the public do not usually penetrate.

Probably the greater part of the cinema audience are only vaguely aware of the fact that the screen conceals one or more very large loud speakers placed directly behind it, and that it is pierced with innumerable holes through which the sound reaches the audience. These holes are so small that they are only visible when the screen is viewed at close quarters.

It is hardly necessary to point out that the long, narrow shape of a good auditorium is conditioned by the fact that the disadvantages of excessive viewing distance are not so apparent as is the painful distortion which results from sitting very near the screen or very much to the side of it.

Probably the most comfortable position in a theatre is in the centre about three and a half to four times as far from the screen as the screen is wide. With film of the present dimensions about 2,000 is the maximum number that can see a film in comfort. Curiously enough, the average British cinema, which seats 950 people, is larger than the average American cinema, which seats 700.

The factors which promote good acoustics in the auditorium are somewhat complicated. Sound, it must be realized, resembles light in that it is reflected off any surface which it strikes. The pages of this book as you read it are lit partly by the light coming direct from the window or lamps, and partly by the light reflected off the ceiling and walls of the room. If black paper were pasted over

the ceiling and walls to absorb all indirect lighting the room would be uncomfortably dark even on a fine day, and if it were lined entirely with mirror glass it would be somewhat dazzling even on a dull day. Good interior decoration involves a compromise between the two extremes. Similarly good acoustic planning involves a compromise between the 'dead' effects which would result from filling the room with sound-absorbing

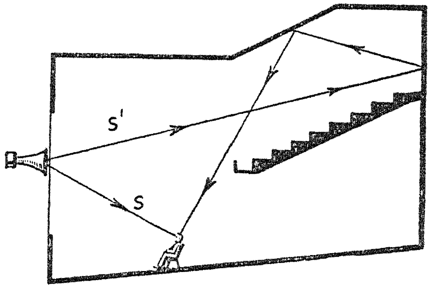


FIG. 27. Acoustic Echo.

materials such as carpets, curtains, and cork slabs, and echoing effects which characterize enclosures containing large flat sound-reflecting surfaces, such as gymnasiums, indoor swimming-baths, and indoor skating-rinks.

There is, of course, only a loose analogy between the drawbacks of too much reflected light and those of too much reflected sound. The time-lag between the arrival of direct light and indirect light is far too short for the eye to appreciate it. Sound, however, travels more slowly, and the ear is conscious of the fact that reflected sound reaches it later than direct sound. In correctly adjusted conditions this awareness confers an agreeable richness on the sound. Wrong conditions, on the other hand, may lead to echoes which interfere seriously with the original sound. Fig. 27 shows conditions in which the reflected sound-wave *S'* will have travelled nearly four times as far as the direct sound-wave *S*, so that it might easily, in a large building, reach the ear after an appreciable interval as irritating repetition of every sound from the speaker.

To guard against this sort of possibility the plaster which lines the walls and ceilings of cinemas is usually broken up into combinations of small planes which break up the echoes.

Another point required to ensure good acoustics is that the sound absorption of the auditorium should vary as little as possible when the house is nearly empty and when it is nearly full. This is accomplished by designing seats with back cushions padded to such an extent that, as far as sound absorption is concerned, there is little difference between them and the body of the average film-goer.

Plate 10 shows an unfamiliar view of a cinema auditorium, the auditorium as seen from the screen, the view which the figures on the screen would look out on if they were real human beings. The ribbing of the plaster for acoustic purposes catches the eye. The row of square projection ports, which usually escape the notice of the audience, can hardly be overlooked from this angle. Beyond these ports lies the projection room, of which Plate 10 also shows a typical interior. A surprisingly large number of machines stand in a row, but three only of them, those in the centre, are cinema projectors. The others are slide projectors for screening announcements, effects projectors for flooding the screen with coloured light, and spotlight projectors for use when stage performances are being given. The use of even three cinema projectors in one theatre might appear lavish to the layman, but actually at least two are needed to give an unbroken show because the length of a single-feature film far exceeds the length of spooled film which is permitted by the regulations to be loaded on to each projector. Each spool takes a maximum of 2,000 feet of film, while a full-length film will reach a length of 6,000 or 7,000 feet. The secret of the apparently unbroken flow of images on the screen is the speed with which a second projector is turned on after the first projector has been turned off. Theoretically this could be accomplished by the use of two projectors only, but the addition of a third gives a stand-by in case of mechanical trouble.

In order to provide the operator with a cue notifying him of the approaching change-over, a mark is made on the film, which appears for an instant as a round dot near the top right-hand corner of the screen. It is assumed that the signal's appearance is too unobtrusive to catch the attention of the audience.

The projection box strikes the eye as a bare, inhospitable-looking interior, especially if the eye comes fresh from resting on the plush seats and lavish trappings of the auditorium. Its principal wall-decorations are notices which prohibit smoking and speaking. Its bareness is strictly utilitarian, and results from the need of banishing all objects which might either harbour dust or sustain a fire.

Dust in the air would tend to settle on the film and scratch its surface as it passed through the machine, while fire is, of course, the perpetual bugbear of projection with ordinary celluloid film. The extreme heat of the arc-lamp and the extreme inflammability of celluloid inevitably involve fire-risk, but the precautions which are compulsorily taken are so complete that it is extremely rare for a film to become ignited, and quite impossible for flames or even smoke to spread from the projection box to the rest of the building. The port-holes through which the projectors throw their beam are closed with thick glass over which iron shutters drop when they are not in use.

To watch the projectors in operation inevitably arouses a sense of the uncanny lack of connexion between the look of the machine and the kind of work which it performs. No one could suppose that a steam-hammer was meant for anything except hammering, and an aeroplane not only flies, but even when on the ground suggests the idea of flying to the eye. With cinema projectors it is different, however. There is nothing in the appearance of the machine as it stands there whirring gently and producing a masked glow from its lamp-house to suggest that it is actively engaged in creating on the screen the enormous picture which one glimpses through the observation port, and simultaneously

filling the theatre with the great volumes of sound which reach the ear in the projection room, suitably diminished, through the medium of a little 'monitor' horn. In fact, if there is any place in the world where things 'are not what they seem', it is the cinema projection box. The tall black-japanned metal cases which stand against the back wall look singularly passive. No one would suspect them of being at work multiplying electrical energy. Apart from the presence of a few knobs and dials, they might be mistaken for the cupboards in a suite of modern office furniture. Yet they are the amplifiers which increase the minute current produced by the photo-electric cell to the strength required for working the loud speakers. In an adjacent chamber a curiously shaped glass bulb 6 feet high glows through its whole interior with a fierce blue mass of light. Certainly the uninitiated could never guess that the function of this fantastic glow-lamp is to create one-way traffic for the electrons conveying the electricity supplied by the local power-station. The power-station supplies alternating current—that is to say, current which flows first one way and then the other—and the glow-lamp is a mercury vapour rectifier which produces a one-way flow of current, usually called 'direct current', by blocking all the impulses of current in the opposite direction. This 'direct' current is required to feed the arc-lamps of the projectors. The mercury vapour rectifier, though the most picturesque type, is not the only type used for this purpose. Some theatres employ the copper oxide rectifier, which to the eye is merely a set of solid-looking metal sandwiches. Others again use a rotary converter, an instrument which combines on a single main spindle an electric motor driven by the main supply and a dynamo generating direct current of a suitable voltage for the arc supply.

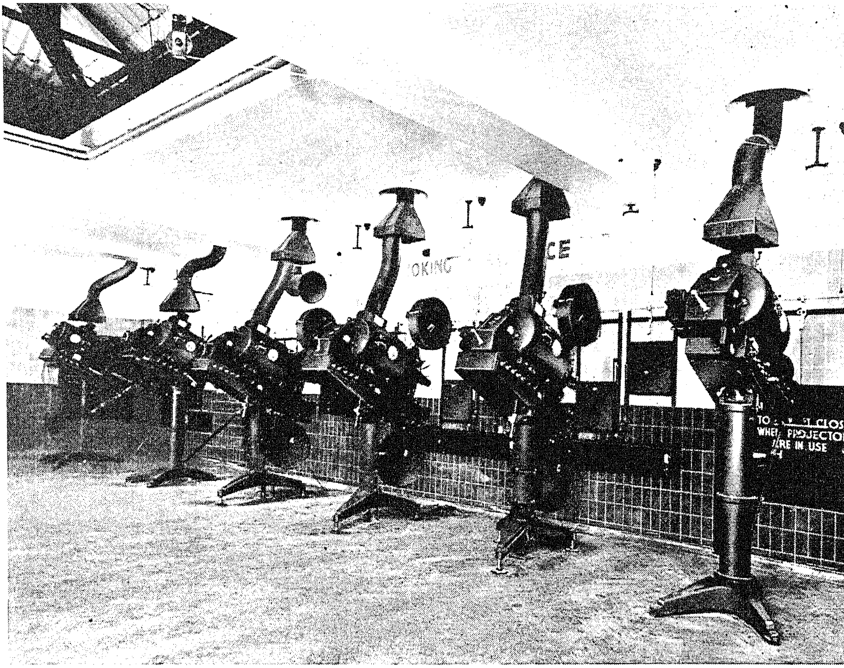
Finally, as has been mentioned in Chapter VI, the possibility now exists of using alternating current in an arc of moderate intensity.

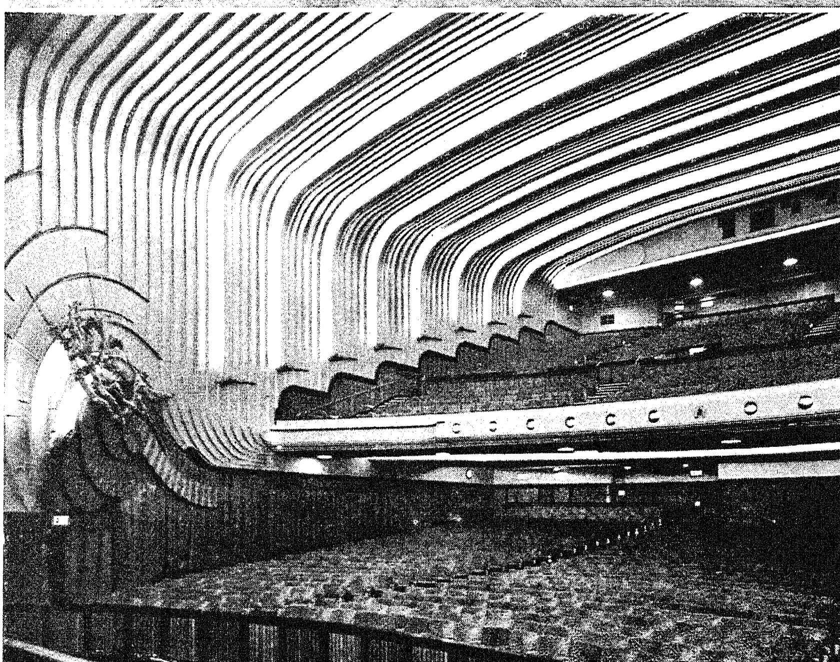
No account of a present-day cinema would be

A picture theatre of twenty-five years ago

A Modern Exterior—Dreamland, Margate

Photo by courtesy of Architecture Illustrated





THE ODEON THEATRE, LEICESTER SQUARE

Above: Projection Room; *Below:* Auditorium from the Stage. Note in the lower picture the projection portholes high up in the back wall, and the ribbed plaster side-walls designed to break up echoes *Photos by courtesy of Sound Equipments, Ltd.*

complete without some mention of the cinema organ used for providing musical interludes. This instrument, with its uncanny habit of rising into view through a hole in the floor, bathed in a blaze of garish spotlighting, has been immortalized in Walt Disney's delightful cartoon *The Goddess of Spring*, where it forms one of the most impressive furnishings of the Demon King's domain. Until recently cinema organs differed only in their outward appearance from other organs. A new type, however, is now being introduced which is based on electrical action similar to that of the film's sound-track, and uses as its final outlet the same loud speakers. Such an instrument consists in essence in the means of producing and mingling at will electric currents with the largest possible range of frequencies within the compass of audible sound-waves.

The architect of a cinema has not only to provide space for all the paraphernalia of film-showing, music-playing, and perhaps theatrical entertainment; he has also to provide means of keeping the public warm while they are in the auditorium and of giving them a good supply of pure air. This is accomplished by an impressive battery of installations in the basement of the building. Here, in addition to central-heating plant, one will generally find air-conditioning plant, comprising powerful fans drawing through a cascade of clean water the air which is about to enter the auditorium.

Sometimes, of course, exceptional positions for theatres present the architect with exceptional problems. Great difficulty, for example, was experienced in isolating the little cinema which is built into the fabric of Victoria Station, London, from the noises inevitable in a large terminus. The solution found was to stand the theatre up on four steel posts, the feet of which were bedded into sound-damping material. The framework of the theatre was interlaced with the framework of the station in such a way that rigid contact between the two structures was everywhere avoided, as otherwise sound vibrations would inevitably have been

transferred from the station to the theatre. Then the theatre was provided with sound-proof walls and roof, and as a further precaution against sound transmission, the floorboards were laid down loosely instead of being nailed.

CHAPTER VIII

COLOUR CINEMATOGRAPHY AND STEREOSCOPY

LONG before the photographic emulsion was fit for the task men were attempting to use it to record the colours of nature. After many false starts it was realized that attempts at recording the colour by direct means, that is causing yellow light to produce a yellow image, green light a green image, and so on, were unlikely to become practicable, since, although substances are known which are changed by exposure to colours corresponding more or less approximately to those of the exposing light, the exposure required is at the best of the order of five to ten minutes in bright sunlight.

Accordingly in commercial processes of colour cinematography no attempt is made to reproduce the *actual* colours of the original subject but only to match them, by mixing the so-called primary colours in suitable proportions. Most people are aware that when an artist is painting a picture he need use very few actual pigments; indeed, only three are absolutely necessary, magenta, yellow, and cyan blue, and all the other colours can be matched by mixing suitable proportions of these basic colours. If, instead of mixing pigments as an artist does, we mix coloured lights, again it is found that only three colours need be used, namely, red light, green light, and blue-violet light. White light itself is a mixture of all visible radiations, its composite nature being beautifully demonstrated by passing it through a prism, when it is dispersed into the rainbow-coloured band we call the spectrum. This spectrum can be roughly imitated by shining patches of red, green, and blue-violet light side by side on to a screen. Where the red and green lights overlap the screen will appear yellow, and where the green and blue-violet lights overlap the screen will appear cyan blue. If now the patches of light are superimposed the resulting mixture will be white, since each coloured light contributes one-third

of the white light spectrum. Unlike the ear, the eye is not an analytic organ, and it is unable to detect the composite nature of white light, or, for that matter, of any coloured light.

The fact that all colours can be matched by mixtures of three colours only simplifies the problem of colour photography considerably, since all that we require is some means of dividing up the light reflected from a coloured object in such a way that records are obtained corresponding to the proportions of the primary colours necessary to match the original colour. If now these records are converted into the primary coloured pigments, magenta, yellow, and cyan blue-green, or, alternatively, into the primary coloured lights, red, green, and blue-violet, and then combined, we shall have made a match to the natural colour.

In order to carry out the preliminary analysis, the subject is photographed three times through filters each of which transmits one-third of the spectrum. These filters will be red, green, and blue-violet in colour, and each photograph is a record in black silver of one of the primary colouis. If now positive prints from these negatives are projected in register on to a screen, each positive being illuminated by light of the same colour as the filter used when making the parent negative, a close approximation to the colours of the original subject will result in the composite picture. Since the coloured result is obtained by adding together appropriate proportions of the primary coloured lights, this method is known as 'additive'.

The earliest attempts at colour cinematography were based on this observation (1897). In front of the camera lens was fitted a rotating filter, with red, green, and blue segments, and so geared with the mechanism that each neighbouring frame on the film was exposed through a neighbouring colour filter. A black-and-white positive print from this negative was then projected through a similar segmented filter. The red-filter positive image was in the gate when the red segment was in front of the projection lens and so on, and the succession of primary

coloured images fused into a 'natural colour' picture as a result of persistence of vision. Such a system was found to be of no value in practice, because any detectable movement in the subject photographed during the period required for the exposure of three successive frames was rendered as an intolerable coloured fringe around the moving object, since only when the images on three successive frames are identical in shape will they register on the retina.

In an attempt to minimize this drawback, the negative has been exposed and the print subsequently projected at up to three times the normal speed. This expedient, although it reduces the difference in position of moving bodies as recorded by successive frames, does not eliminate it, and the normal observer is more intolerant of detectable colour-fringes, however small, than of quite gross errors in colour rendering (flesh tints perhaps excepted).

Some of the difficulties of successive additive projection can be minimized by dividing the spectrum into two rather than three parts and attempting to match natural colours by using varying proportions of these two colours. One can either abandon the blue record entirely, or, by using a blue-green taking filter, record the blue and green rays on the same frame. Whichever method is adopted in taking, the projection filters must be complementary in colour if a pure white is to be obtainable, and when this is the case, the colour rendering is limited to two dominant hues, namely, those of the filters themselves. Such a colour rendering is hardly 'natural' and, accordingly, attempts were made to record all three images simultaneously on neighbouring frames of the film by means of three-lens cameras, the positive film being subsequently projected in a three-lens projector. In 1912 the Gaumont Company demonstrated an additive three-colour system of this type at the Hippodrome, Paris, but although the colour rendering obtained was excellent, their daily projections emphasized another serious difficulty. In the Gaumont camera the three separate lenses behaved as do the lenses on a

stereoscopic camera in that they recorded slightly different views of the subject, and fringing due to time parallax was replaced by fringing due to stereo-parallax.

In order to render this fringing as unnoticeable as possible, an observer was stationed in the prompter's box, which was only a few feet away from the screen, and it was his duty to keep the principal object in each scene in register by operating electro-magnetic controls, which gave vertical or transverse movements to the lenses as required during the projection. In the hope of escaping this nightly drudgery, the operator constructed apparatus which registered the nature and extent of the corrections he was obliged to make throughout the showing of the film, and which would give these corrections automatically at subsequent performances. Unfortunately, however, as each primary coloured filter is absorbing at least two-thirds of the light falling on it, in order to obtain an adequately lit picture it was necessary to use a much more powerful arc lamp than was required for black-and-white, and the film shrank appreciably each time it passed through the exceedingly hot gate. As a result, the corrections given by the automatic device only sufficed for one further showing. Since that early and very striking demonstration, many methods have been proposed for overcoming errors due to stereo-parallax, though most of them merely substituted other drawbacks; the images were freed from stereo-parallax, but were of slightly different sizes, or the optical system was only capable of giving sharp focus over a limited depth of field.

Du Hauron, a Frenchman who had visualized practically every workable system of colour photography by the end of the last century, suggested an exceedingly ingenious way of avoiding these difficulties which, in the case of cinematography, has been commercialized as the 'Dufaycolor' process. In this process all three primary records are made upon the same film through a microscopic mosaic of primary colour filters printed on the film base. The individual filter elements are too small to be seen by the naked eye, for there are over one

million per square inch, and the mosaic, or 'reseau' as it is called, appears a neutral grey colour. The film is fed into the camera gate with the base towards the lens so that light on its way to the emulsion must first pass through one or the other of the filter elements. When a red object is filmed, the red rays from the object pass unhindered through the tiny red elements of the mosaic and affect the emulsion, with the result that after development there is an opaque silver deposit exactly underneath each red element. The red rays are, however, absorbed by the green and blue elements and the emulsion under these elements is, therefore, unaffected. The developed film is now placed in a solution which dissolves out the developed silver image but leaves the unexposed emulsion unaffected. After leaving this bath, therefore, the film is transparent under the red elements. The unaffected emulsion under the green and blue elements is now blackened by a second bath, and in consequence, when the film is viewed by transmitted light, the latter is only able to pass through the red-filter elements (see Frontispiece).

In the case quoted we have considered the reproduction of a red, which is spectrally simpler than the red of the colour mosaic. The majority of the colours are, of course, more complex than this, and varying proportions of the constituent rays will pass through all three elements, producing varying degrees of opacity behind these elements, which, after the reversal process, become varying degrees of transparency, allowing appropriate proportions of each of the three colours to pass. These are blended on the screen to reproduce the original colour. The sub-standard Dufaycolor film used by amateur cinematographers is processed by reversal of the camera exposure to a positive in the manner described above.

Providing, however, appropriate precautions are taken, camera-exposed Dufaycolor film can be developed to a negative image and fixed at this point. This negative film can then be printed on to Dufaycolor positive stock to give the positive release prints, and 35-mm. Dufaycolor is now processed in this manner.

Subtractive Processes

In additive processes we start with a dark screen and build up a picture by adding together coloured lights coming from what are, in effect, three separate light-sources, the black silver deposit in the positive transparency controlling the amount of each primary coloured light which reaches the screen. In nature, substances are not coloured in this way, but instead they absorb or subtract certain portions of the visible spectrum of white light and reflect the remainder. It is this composite, reflected portion which enters the eye and gives rise to the sensation of colour, and this phenomenon is the basis of the 'subtractive' processes. In such processes we start with a single source of white light and subtract from it the unwanted radiations. This is what happens when an artist paints a picture. He covers the surface of white paper with layers of pigment which function by absorbing all light reflected from the paper surface except those rays whose effect on the eye we call the 'colour' of the pigment.

In a three-colour subtractive process, therefore, the image on the film must itself be coloured, and is built up by superimposing in register images in the artist's primary colours, yellow, magenta, and cyan blue, each of which is printed from a separate negative record. The relation between the subtractive printing colours and the negative record made by red, green, and blue light is perhaps made clearer by analogy with black-and-white photography. When we take an ordinary monochrome photograph by white light we make prints from it with a pigment which represents absence of white light, namely, black. In subtractive colour photography the negative record made by red light is printed in a colour which represents 'absence of red light', and this colour is cyan blue. Similarly the green-filter negative is printed in a 'white light minus green' colour, which is magenta, and the blue-filter negative in 'minus blue' or yellow pigment.

There is no simple way of producing these three-

coloured images in one emulsion layer, and accordingly the earlier forms of subtractive process were two-colour approximations which relied on the fact that a film has two sides, each of which could bear one coloured image. Again it was the blue-filter image—which in the subtractive processes is the yellow printer—which was sacrificed, but some compensation for its absence is obtained by adding some yellow to the pink printer (printed from the green-filter record), making it orange, and to the blue-green (printed from the red-filter record), making it green. As a result, a greater range of colours is obtainable by the two-colour subtractive systems than with two-colour additive. If the additive viewing (projection) filters were modified in this way, the whites would be rendered as yellow, since the two filters would no longer be complementary. It can only be done in the subtractive process, because the whites are here due to clear spaces on the positive print and derive their colour from the viewing (projecting) light, which is white.

In the earlier forms of two-colour subtractive processes the negatives were printed on double-coated stock (1912). There are a large number of methods available for toning or otherwise transforming the separation positive images printed in register on either side of this material into the orange and green or blue-green two-colour primaries, and the best of these still survive for the production of advertising shorts and cartoons.

Although the range of hues which can be attained is greater in two-colour subtractive than in two-colour additive systems, the compromise with truthful rendering is still obvious, and were it not for the relative cheapness with which two-colour subtractive films can be made, it would be safe to predict their rapid disappearance. As it is, however, until 1933 they formed the only commercial colour processes to attain any sort of success with the public, and probably reached their high-water mark with the Technicolor production of *Gold Diggers of Broadway*, which made £900,000 for its backers (1930).

The easiest way of obtaining the two negatives necessary for two-colour processes is by means of a bipack. A bipack consists of two films which travel through the camera gate either with their emulsion surfaces towards the lens or in contact face to face. The front film is semi-transparent and is sensitive only to blue and green light. The front and rear films are separated by an orange-filter layer which prevents all but orange-red light from passing through to record on the rear panchromatic emulsion (Fig. 28).

The most serious drawback to the earlier forms of bipack was the lack of definition of the rear image. This image is recorded through the fog of emulsion grains which makes up the front layer, and the consequent scattering of the transmitted light was very obvious with full exposures and in long shots where the definition of small objects was noticeably lacking. The Technicolor Company were making commercial two-colour films before bipacks were a practical proposition, and they obtained their negatives in a beam-splitter camera which exposed two frames simultaneously (Fig. 29). A 'skipping' printer was employed to collect the two records on to two separate films from which the colour images were printed.

This camera had the advantage of giving two critically sharp negatives, and in 1929 Technicolor introduced a further improvement by abandoning the use of images situated on opposite sides of the positive film for imbibition printing on to one side. In the imbibition process, positive prints from the original negatives are exposed through the celluloid base and so processed as to produce positive relief images in hardened gelatine. Each relief image is soaked in an appropriate dyestuff solution and then brought in turn into intimate contact with a film of plain gelatine to which the dyestuffs transfer, building up a subtractive coloured image.

The adoption of this type of printing process cleared the way for the production of three- (and hence 'natural') colour films. Actually, however, Technicolor's first commercially successful three-colour films were Disney's

Silly Symphonies, the reason being that the making of the three necessary negatives presents no particular difficulty in the case of a cartoon film, since each negative can be exposed independently and under easily controlled conditions.

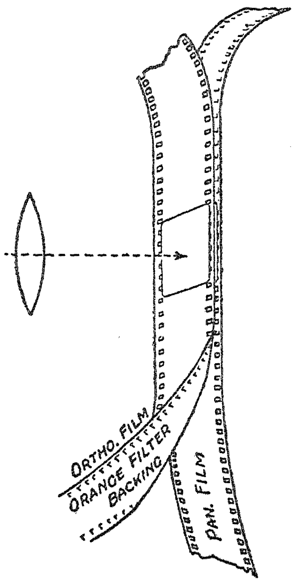


FIG. 28. Bipack.

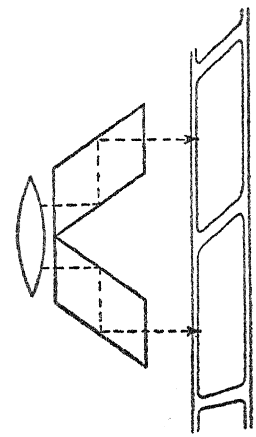


FIG. 29. Beam-splitter.

Meanwhile, Technicolor were perfecting a camera in which the principles of split-light beam and bipack were combined to give three-colour negatives under studio conditions. The method by which the three records are made simultaneously will be clear from a study of Fig. 30, which shows a phantom view of the optical system of this camera.

The history of the Technicolor Company is an interesting one, for its career has consisted of logical steps well thought out, each of which has brought it nearer to the goal visualized from the start. Moreover, unlike most pioneers, the company stands a good chance of reaping reward for its uphill struggle since it has a virtual monopoly of the feature film market, in so far as

that market is at present interested in colour. It is possible that the next advance will be the substitution of an ordinary camera for the cumbersome and expensive three-colour camera. This substitution is verging on the practical as a result of the successful working out of

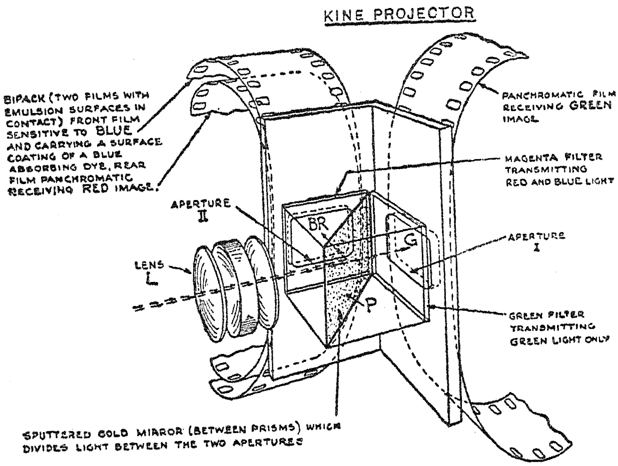


FIG. 30. The Optical System used in Technicolor's Camera.

The gold-flecked mirror on the face of the prism splits the light from the lens into two beams. The rays transmitted by the mirror pass through a filter which absorbs all but green light which then records on the single film. The light reflected by the mirror passes through a pink filter which absorbs green light. The blue rays passed by this filter record on the front film of the bipack, whilst the red rays pass through the front film which is not red-sensitive and record on the near, panchromatic film.

systems of subtractive colour cinematography known as 'monopack' or 'integral tripack' processes. It has been pointed out that, in a normal bipack, the rear image is not critically sharp, and proposals for exposing three films as a pack are, therefore, unpromising, since the definition of the third film would be intolerable at cine magnifications. Even if the three emulsion layers are very thin so that light-scatter by the emulsion grains is reduced, the air surfaces separating the films still cause a serious spreading of the transmitted light as a result

of inter-surface reflections. However, by coating three emulsions on top of each other, each emulsion being about one-third of the usual thickness, light-scatter is very materially reduced, and indeed the scatter which does occur will obviously be no greater than is the case in a normal emulsion of the same thickness.

The problem of using such a material for colour cinematography has been tackled in several ways. Gasparcolor film, for example, is coated with three layers of emulsion, each of which is coloured throughout its mass in one of the subtractive primary colours. The blue-green coloured emulsion, which is sensitive only to blue light, is coated on one side of the film, and the yellow-coloured emulsion, which is sensitive to red light, on the other. On top of the yellow layer is coated a magenta-coloured emulsion, which is only sensitive to blue light.

Printing takes place from three separation positive films by means of appropriately coloured lights. Thus, when the yellow-printing separation positive is printed on to the film by means of red light, this light does not affect the top magenta, blue-sensitive layer, and the image is, therefore, only recorded in the middle yellow-coloured layer. The magenta and blue-green printing positives are then printed by blue light on to the outer magenta and blue-green coloured emulsions. The exposed film is developed and then treated with a reagent, which converts the silver image into silver bromide—an operation which causes the dyestuff in the immediate neighbourhood of the silver image to bleach. The silver halide is then fixed out, leaving a subtractive three-colour positive image. Gasparcolor multi-layer film has, so far, only been used as a printing material, for it is too slow for use in the camera. Moreover, the ideal material would have all three images on the same side of the support.

Kodachrome, the process developed by Mannes and Godowsky in the Eastman Kodak laboratories, is a material of this type. Kodachrome film (1935) is built up of three emulsion layers, but these are coated on the same side of the support and are not coloured, but only

specially sensitized. The layer nearest the film base is panchromatic emulsion, sensitive to red light. Above this, and separated from it by a very thin coat of gelatine, is an orthochromatic emulsion sensitive to green light, whilst the top layer is a non-colour sensitized emulsion which, therefore, only responds to blue rays and is separated from the orthochromatic layer by a clear, yellow filter coating. When this 'integral tripack' is exposed in the camera the blue rays proceeding from the subject record on the top layer, the green rays on the middle layer, while the red rays pass through both these layers and affect only the bottom emulsion. The film is developed and the negative image is dissolved away as in the normal reversal process. It then passes through a series of tanks in which the following operations occur:

(1) All three reversal positive-images are developed in a special colour developer which produces a blue-green image in each layer. Colour development depends on the fact that when developers reduce silver halides they are themselves oxidized. In the case of pyrogallol, the oxidized product is familiar to most photographers as a yellow-brown image which remains when the silver is subsequently removed. The three Kodachrome developers have oxidation products which combine with a chemical agent in the developer to give insoluble dyes of the primary subtractive colours.

(2) The two top images are bleached and redeveloped in a magenta-colour developer, the underlying blue layer not being attacked because the bleaching and colour developing solutions are only applied for sufficient time to allow them to penetrate the two top layers.

(3) The outermost magenta layer is rebleached and redeveloped in a yellow-colour developer, and again the manipulations are such that these solutions only affect this outermost layer. The silver image is then removed, and the film ready for projection, therefore, carries a colour image built up

of three layers coloured blue-green, magenta, and yellow.

Agfacolor subtractive cine-film (1936) is also an integral tripack, and a similar final result is obtained, but by somewhat different means. The Agfa process is based on the discovery that a single, specialized form of developer, containing one of the essential components of a series of dyestuffs, will react with the other constituents included in the emulsion during manufacture to produce insoluble colours wherever a silver image is developed. The colour produced depends upon the nature of the second constituent.

That constituent which reacts with the developer (or its oxidation products) to produce a yellow, say, is incorporated during manufacture in one of the layers of the multi-layer film, the other constituents which combine with the same developer to give the magenta and blue-green images being included in the other two layers.

After exposure the film is developed to a negative in an ordinary developer. The film is then exposed to light, and the residual silver halide, which, of course, corresponds to the 'reversal positive' image, is then developed in the special 'dye-coupling' developer, whereupon the coloured dyes which build up the picture are formed, one in each layer. The black silver image is then dissolved away, leaving a subtractive colour picture, built up from these dye images.

Negative Material

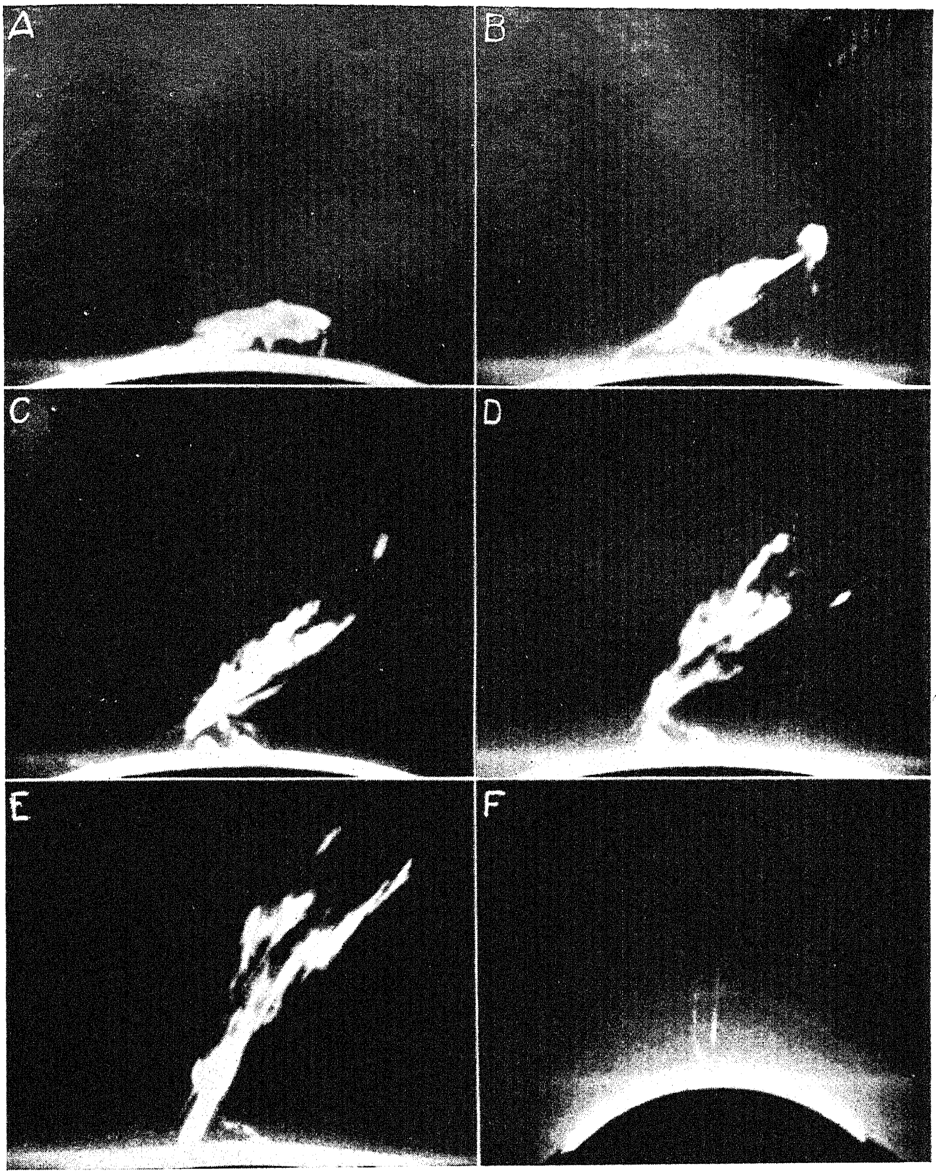
In the Kodachrome and Agfa processes the camera exposure is converted into the projection positive, and the systems have so far been of interest only to the substandard amateur worker. Recently, however, the successful duplication of Kodachrome has been announced, and the introduction of monopack colour processes into the commercial field thus becomes a possibility. Kodachrome and Agfacolor are already available in the form of the short lengths of 35-mm. film used in miniature-camera photography. By printing such miniature-

camera colour transparencies on to panchromatic emulsions, using suitably chosen red, green, and blue printing lights, separation negatives are obtained which can be used for making colour prints on paper. A suitable modification of this technique would enable Technicolor imbibition prints to be made from separation relief positives extracted from monopack 35-mm. film exposed in an ordinary cine-camera.

It is unlikely, however, that such a development will rapidly put the present beam-splitter Technicolor camera on the museum shelf, for the separation images derived from the very thin emulsion coatings of monopack film are not yet of a quality comparable to present-day Technicolor negatives. On the other hand, for newsreel work and other occasions where flexibility and portability of the camera are primary considerations, the monopack material would have very decided advantages. In 1939 Kodachrome prints made on 16 mm. film from three-colour separation film negatives made in the Technicolor Camera were marketed in the U.S.A.

The future which may lie in front of the processes we have outlined cannot be estimated on the basis of our present knowledge. At the moment each has its particular advantages and drawbacks. Generally speaking, additive systems are cheaper and easier to process at the negative and at the positive stage. Their big disadvantage is that they require considerably more light for successful projection than do subtractive films, while the pattern of the mosaic screen used in Dufaycolor, although invisible from the better-priced seats in the theatre, is still very obvious to the 'sevenpennies'. The subtractive processes require no more light for successful projection than monochrome nor is there a screen pattern to worry about. On the other hand, the making of suitable separation negatives for subtractive printing is a relatively difficult matter, and the processing operations are more expensive than in the case of additive systems.

Apart from difficulties peculiar to each process, there are some which are common to all systems of colour



Time-lapse Motion Picture of Great Solar Prominence of Sept. 13, 1937, which lasted about 80 minutes and reached over 620,000 miles in height

By courtesy of the McMath-Hulbert Observatory of the University of Michigan

From 'Night Mail'—A G.P.O. film describing the night journey of the postal special from London to Edinburgh

The film incorporates an interesting sequence of descriptive verse by W. H. Auden

By courtesy of G.P.O. Film Unit

From 'Song of Ceylon', directed by Basil Wright for the G.P.O. Film Unit: a lyrical description of native life and the impact on it of modern civilization

By courtesy of the National Film Library

cinematography. Considerably more light is necessary for the exposure of the original negatives—the additional amount being approximately the same for both additive and subtractive systems. Appreciable improvement in working speed is dependent upon research into photographic emulsion making, rather than colour processes as such, and any gain will, therefore, probably be equally applicable to all processes. This point is worth stressing, because one is continually hearing of new systems of colour cinematography which are said to require at the negative stage 'much less light than any known system'. When, as is usually the case, this gain is at the expense of the saturation of colour rendering, it represents a step available to any process whose sponsors believe that robbing Peter will satisfy Paul.

It is true that there are, at the moment, differences in the working speed of the various forms of negative material, but they are such as to provide a 'talking point' rather than a material contribution to this aspect of the problem. As it is, the additional light required is a serious problem, and it is interesting to reflect that, whereas with the introduction of sound, film making was driven into the studios, and Hollywood, because of the curse of Babel, began to lose its monopoly grip on the industry, the reliable Californian sunshine may, at first, tip the scales in favour of America again when colour production starts in earnest.

Although we have indicated some of the technical drawbacks of present-day colour systems, it is necessary to emphasize that these are not of fundamental importance, since none of them is incapable of solution. None of the processes described is up against the stone wall of the demonstrably impossible, or the knowledge that its ultimate possible achievement has already been surpassed by processes based on different principles. Moreover, the survival value of any particular process is largely dependent on factors which have little to do with its technical efficiency. Our weights and measures, our clothes, our meals, our economics, and our politics are demonstrably irrational. Accordingly, rather than

venture on prophecies as to the future of particular systems, let us examine our reactions to the colour film as it is at the moment.

It is, perhaps, significant that Disney's Silly Symphonies are the only colour films which have so far received general approval. How much of their success is due to the fact that cartoons are the only films so far produced in which the colour is completely under the control of the producer and how much to Disney's genius, we do not know. It is at least arguable that those critics who are of the opinion that the only real future for colour cinematography lies in the non-realistic colour cartoon are merely paying a tribute to the high level of technical quality which has been attained in that medium, rather than making out a case against the general use of colour, and we must be careful not to draw sweeping conclusions about the future of colour on the basis of a justifiable distaste for imperfect colour cinematography handled in the florid manner which is now so usual.

The simplest way of looking at the matter is to imagine that colour photography had been invented before monochrome photography. If this had been the case, we should by now be so used to colour, and understand so much better how to handle it, that the discovery and substitution of monochrome would seem a retrograde step, except perhaps for special effects. To complete this inverted picture it is necessary to assume that the newly introduced monochrome process was of a photographic quality equivalent to the average news films, for this is the level of quality which, in our opinion, colour, by any process we have so far seen, has attained.

The critics to whom we have referred would then almost certainly protest that we are not colour-blind, and that the suggestion that this newfangled monochrome would eventually oust the familiar colour film was ridiculous—that at the most it should only be used for special effects, such as the line-drawing cartoons of Disney!

Looked at in this way, the answer to the question 'Do we want colour?' is 'Naturally', though we are not necessarily going to prefer the colour productions of the next few years to monochrome. The latter has had an excellent start, and thirty years of 'trying it on the dog' has evolved a technique of presentation admirably suited to the black-and-white medium. Producers, cameramen, and directors have grown up in a black-and-white universe, and to take their product in its present form and colour it can hardly be more successful aesthetically than would be the fitting of dialogue to a silent film. The moment sound released the film from the frustration of the sub-title, the film began to alter, and one has only to see a modern talkie without its sound accompaniment to realize just how much the film's present architecture is conditioned by its appeal to both eye and ear. Early sound-films, judged by present-day standards, were intolerable; the films themselves were little more than photographed stage plays in which action was slowed down to permit of a spate of talk and noise. Many people firmly believed, therefore, that the talkies would prove a short-lived boom. On the other hand, the reorientation of ideas and production methods which rapidly followed was easier to bring about than will be the reorganization demanded by colour, and analogies to the 'talkie revolution ' are, beyond a certain point, misleading.

The sound-film introduced a new set of dramatic values upon which producers were quick to seize. It was only rendered possible by the direct application of discoveries and experience accumulated by the radio industry, and its imperfections were soon reduced below the point where they distracted our attention from the theme of the film. A slight distortion of truth in the reproduction of sound is not necessarily fatal to our enjoyment. The fact that an actor's voice, as reproduced from the sound-track, may be markedly different in timbre from his actual voice will pass unnoticed, but equivalent distortion of flesh-tone colour rendering might turn this to an unforgivable green. Colour

cinematography has no industry equivalent to radio to which it can turn for ready-made solutions of its problems. It must pull itself up by its own bootlaces. Fortunately, the introduction of sound dealt the first serious blow at those empirical methods of working which colour will, of necessity, banish entirely; but a realization that empirical methods are even more disastrous in colour production than they are in sound is hardly sufficient to ensure the rapid disappearance of black-and-white.

Even if we assume that the necessary control over the technical aspects is already attainable, there are many other factors which will influence the development of the colour film and which we have not as yet the data to discuss intelligently. That we shall continue to be satisfied with colour films merely for their kaleidoscopic qualities is doubtful, and so far most producers have attempted to make colour run before it has really learned to walk. It is, for example, arguable that the application of colour to the story film in its present form is aesthetically a mistake, and that the fact that most story films in colour to date have been 'costume pieces' is a confession of technical weakness. It half hints that those responsible doubt the ability of any process to deal as yet with subtleties, and have, therefore, played for safety by clothing the actors in every colour of the spectrum, so that the eye may be stunned into a realization that theirs really is an all-colour film and be blinded by the undeniable colour-range of the actors' clothes to the peculiarities of their complexions! We may be wrong here; available processes possibly are capable of dealing with subtleties; but the backers of a colour film may not be prepared to risk the additional money which colour costs unless they can see with their own eyes that they are getting value for it by the colour acrobatics which the film performs. This attitude is very common with colour photographic workers, as can be seen at any exhibition of still colour photographs. Despite the fact that, in still photography, it is certainly possible nowadays to trap subtleties and

delicacies of colour on paper, glass, or film, many leading colour photographers are still obsessed by the ability of the automatic paint-box to reproduce any colour, however vivid, and they prefer to run the whole gamut of the spectrum rather than work with a limited number of harmonious colours. It is not surprising, therefore, to find that art directors of colour films, who in print maintain that restraint in the handling of colour is essential, can yet set a tea-table with a red and blue checked cloth and surround it with models in yellow and purple hats wearing green and scarlet bathing-costumes! The fact that our adventures to date in the field of beauty have been rather like an excursionists' picnic in a bluebell wood is partially responsible for the attitude of many intelligent people to colour photography and cinematography. It is, however, easier to criticize than to be constructive, and the generalizations which writers on the subject have so far offered to the producers of colour films are of little more practical value than clichés about the desirability of goodwill in international relations.

On the other hand, it is generally admitted that colour will involve alterations—perhaps radical—in our methods of constructing a film.

The modern film, in which rapidly changing scenes are shot from constantly changing angles, yet retains a visual continuity because of its monochromatism—a harmony which disappears with the introduction of a new aesthetic dimension in the form of colour. First attempts at restoring this harmony will probably slow up the tempo just as was the case with the early sound-films. We know very little as yet of the psychological effects produced by constantly changing colour presented in a darkened theatre, beyond the fact that the combination of vivid colour and quick movement gives some people a headache, and that colour photographed at its full value will at first call attention to itself and distract attention from the action of the characters. We also know that colour, while enhancing some effects, may detract from the dignity and impressiveness of

others. We know that the close-up is nearly always more attractive than the long shot, particularly in outdoor scenes; that the producer cannot concentrate attention on his players by throwing his background out of focus, as he does in monochrome. The meaningless blobs of colour in such out-of-focus shots are both worrying and unnatural. The eye will vainly attempt to restore the missing detail, and anything which calls attention to the technical or mechanical features of a screen production is admittedly a handicap. In fact, whereas in monochrome we have a highly developed means of artistic expression, in the colour film we are still fumbling among first principles.

The producer, then, is on the horns of a dilemma. If, as many of us would prefer, he aimed at producing a film in which the contribution made by the presence of colour, as such, remained almost unnoticed—except in our heightened appreciation of the production as a whole—he is gambling perhaps £25,000 of his backers' money that the process will not let him down—that this heightened appreciation will, in fact, result in a feature film earning at least £25,000 more than it would if it were made in black-and-white. It is a gamble which the hard-headed business backers, whose measure of a film's success is its box-office appeal, are hardly likely to take for some time yet.

How, then, are we to acquire this badly needed information as to how exactly colour cinematography should be handled?

Since no work of art can deliberately be constructed by the application of formal rules, and since more knowledge of our reactions to colour presented in a time sequence is badly required, a case could be made out to show that the next logical step from the colour cartoon should be to the colour newsreel rather than to full-length story films.

In the newsreel aesthetic considerations have only a rudimentary importance, because the news itself is the important thing, and news in colour would have just that much more specific interest for the audience

that a monochrome photograph, however poorly reproduced in a newspaper, has over a line-drawing however accomplished. During the time that the cartoons develop from the *Playbox Annual* effects of *Old King Cole* to a real colour symphony, the colour news film and documentary might be used to provide reliable data on what Klein has called our 'physiologico-psychological' reactions to films in which the unifying harmony imposed by monochrome presentation is absent, and so help to solve the colour producers' problem and give colour enthusiasts something to talk about besides dyads and triads. On the other hand, a factor which may influence the immediate future of particular processes is suggested by past history. One of the several features which the big moving-picture corporations have in common with a herd of elephants is their liability, when alarmed, to charge as a herd in one particular direction after a leader who has chosen his course, as like as not, by chance. Witness the spate of gangster films, of newspaper-story films, of historical films, which followed upon the first box-office successes made to these formulae. For some years now this herd has had its beady eyes uneasily fixed on Technicolor, not because it particularly wanted to smear the world with colour. Indeed it would prefer to be left alone—and said so.

It had hardly recovered from its surprise at Disney's rise to fame on the basis of cartoons it had seen no reason to suppose would be successful when, aided and abetted by Dr. Kalmus, he 'stole the programme' even more completely by using three-colour Technicolor for his Silly Symphonies.

The herd pricked up its ears, but the stampede did not start because previous dashes into colour had, on the whole, been disappointing. But it only requires that a film, based on a popular story and made by an artist having some idea of the possibilities and limitations of colour as a medium, should 'go over in a big way' for the stampede to start in earnest. Several attempts have been made to start the rush. The sponsors of *The*

Garden of Allah for example, which is reported to have cost half a million pounds and involved 1,500,000 feet of negative film, probably hoped that Miss Dietrich would prove to be the Delilah who would do to monochrome what the jawbone of Al Jolson did to silent films. If so, they were mistaken, but nevertheless, the output of Technicolor feature films is steadily increasing, and the public's reaction is increasingly encouraging.

The suggestion is frequently made that the cinema industry cannot afford colour, but it is doubtful whether this is the case. An industry which can afford to pay salaries that sound like national debts to people who spend a considerable portion of their working hours in kicking their heels, and whose general attitude towards production costs has become Olympic, could, with a little intelligent reorganization, afford the most expensive colour system yet devised.

In conclusion, it is common to bemoan the enormous amount of money which has been spent on research on colour cinematography, and there is little doubt that a good proportion of this money has been thrown away. If all the energy, enthusiasm, money, and prematurely grey hair had been concentrated on a study of two additive and two subtractive systems, rather than been dissipated over an endless variety of different methods, colour cinematography would now be firmly established.

On the other hand, it is doubtful whether the money which has been lost on this subject in the past would pay for even one of those battleships which, having been built, never saw action of any sort and were eventually sold for scrap iron. And a visitor from Mars, when he had finished wondering at the way we run the world, might quite reasonably maintain that the most hopeless research on the problems of colour and colour reproduction was a more reasonable way of spending a lifetime or a fortune than many others we have devised.

We are not suggesting that battleships are unnecessary—merely that they ought to be, and that an intelligent race of animals would feel that their energies were

put to a better use in puzzling over ways and means for making life fuller rather than shorter.

Stereoscopic Cinematography

When we look at the three-dimensional world, the objects we see have an appearance of solidity because we look at them with two eyes, each of which has a slightly different viewpoint. The distances between the objects, their shape, the part of their surface that is seen by each eye are, if the object is three-dimensional, slightly different. The sensations resulting from the two slightly different flat images formed on the left and right retinas are united in the brain to form one impression, and the sensation of solidity is produced in consequence. If for the two eyes we substitute the mechanical equivalent in the form of two cinematograph cameras side by side, whose lenses are about 2 inches apart, one of these will photograph the view as seen by the left eye and the other as seen by the right. If the two films so obtained are projected simultaneously and in such a way that the observer's left eye only sees the left and his right eye the right camera pictures, then the two series of pictures will fuse together in the brain just as normal visual images do, to give a so-called stereoscopic picture which is apparently three dimensional.

When, as in the cinema, the two photographs to be viewed are at least as large as the objects themselves, they will occupy their proper positions in relation to the eye only when they are superposed.

An ingenious way of causing two projected images to fuse was demonstrated in 1855 by Rolhmann and D'Almeida, and adapted to cinematography by Lumiere. This system involves the use of two differently coloured viewing-filters, one for each eye, through which are viewed the stereoscopic pair of projected images each of which is in a colour complementary to one of the viewing filters. When, for example, an orange-coloured image on a white screen is viewed through an orange glass, it is impossible to detect where the coloured image leaves off and the white screen begins, the whole

surface appearing a uniform orange colour, the image itself being invisible. If, however, this orange image is viewed through a blue-green glass, the white surround will appear blue-green, but since orange-coloured light is absorbed by blue-green filters, no light from the image itself will reach the eye and the image will appear black. The orange-coloured image will, therefore, only be seen by the eye covered by the blue-green spectacle. If, now, the corresponding stereoscopic picture is also projected on to the screen as a blue-green image, by the same reasoning, this image will be invisible to the eye covered by the blue-green filter, but will be seen as a black image by the other eye if this is covered by an orange filter.

The necessary condition that each eye shall only see one of the images is thus fulfilled. Moreover, just as the brain fuses the two differently shaped images into one sensation, it also struggles, more or less successfully, to fuse the orange and blue-green rays entering the two eyes into a single sensation, namely, that produced by white light. Under ideal conditions, therefore, these anaglyph pictures, as they are called, appear to be black-and-white stereoscopic images. This method is only suitable for quite short films, since apart from the disadvantage of having to supply the audience with viewing spectacles, the use of two colours results in 'retinal rivalry' between the eyes which is particularly noticeable when viewing large clear areas such as sea or sky, and after five minutes or so eye-strain becomes noticeable. Moreover, the stereo effect produced by anaglyphs is only partial, the subject being divided up into different planes suggesting the flats in stage scenery rather than the roundness and solidity of real stereoscopic vision.

Providing that it is practical for each member of the audience to wear a considerably more expensive form of viewing spectacles, these drawbacks are removed, and, in addition, it becomes possible to see stereoscopic natural colour films. This is accomplished by projecting the two stereoscopic pictures using polarized light. Ordinary light can be considered as a wave

motion whose vibrations occur in all directions at right angles to the direction in which it is travelling. If a beam of ordinary light is passed through a polarizing material all the vibrations in one direction are absorbed and the issuing light is said to be polarized. There are several transparent materials which polarize light in this manner, but it is only recently that it has become possible to produce large, water-clear polarizing sheets from which spectacle disks can be cut. A typical material consists of sheets of cellulose acetate containing millions of invisibly small crystals all orientated in the same way. These crystals act as a sort of filter grid in that they only permit light vibrating in the direction parallel to the main axis of the crystals to pass through. Only fifty per cent. of the light falling on such a polarizing filter will, therefore, be transmitted. Moreover, if a second polarizing screen is placed in the path of the issuing beam, it will absorb the remaining fifty per cent. of the light when the minute crystals of which it is composed are at right angles to those contained in the first filter.

The way in which these facts are applied in the production of stereoscopic films is illustrated diagrammatically in Fig. 31. Suppose that two films, one representing the right- and the other the left-eye view of a scene, are projected simultaneously on to the screen from two projectors side by side. Suppose, moreover, that each projection lens is fitted with a polarizing screen of the type described, but so orientated that the 'right-eye' projector only projects the horizontal light vibrations and the 'left-eye' projector the vertical vibrations. The alteration in the nature of the light falling on to the screen will not be obvious to the audience until they view the screen through a pair of polarizing spectacles so orientated that the left-eye spectacle only transmits vertical light vibrations and the right-eye spectacle only horizontal vibrations. Through such a pair of spectacles, the left eye will not see the right eye picture and vice versa, and the condition necessary for stereoscopic vision has, therefore, been fulfilled.

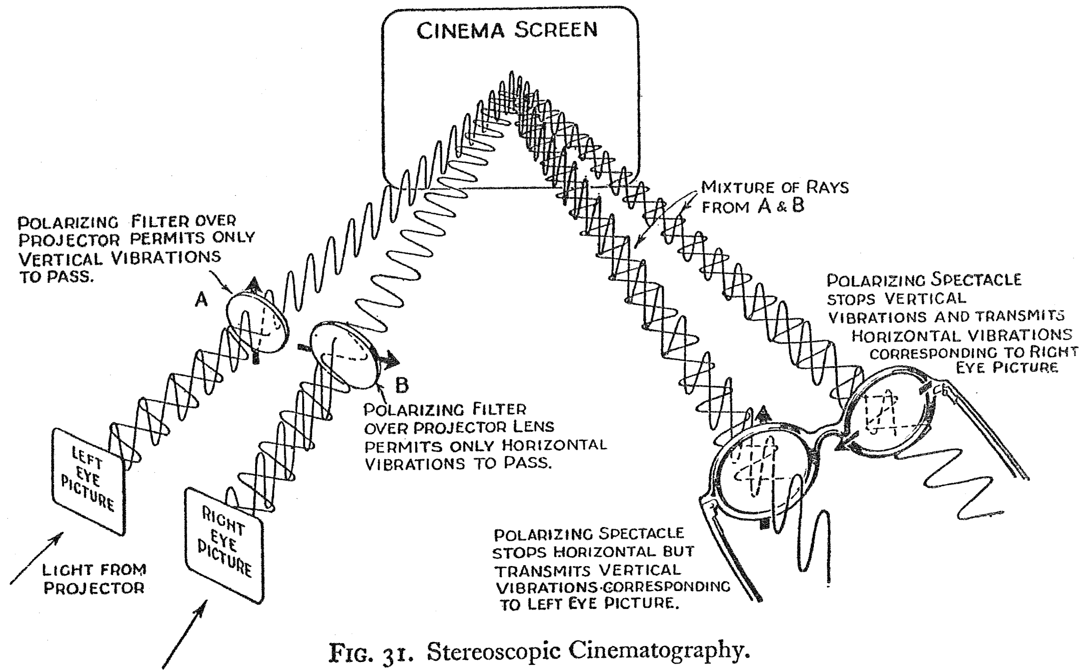


FIG. 31. Stereoscopic Cinematography.

A stereoscopic picture is obtained by viewing polarized light from two projectors through polarizing spectacles. Light proceeding to the screen from the left-eye picture is polarized by the polarizing filter A in the direction at right angles to the light going to the screen from the right-eye picture via the polarizing filter B. Light reflected from the screen to the audience and which has come via A can only pass through the left eye spectacle. Similarly only light coming via B can enter the right eye through the right-eye polarizing spectacle whose orientation is the same as B.

When stereoscopic films made in natural colour are projected in this way, the illusion of reality is complete. Such films are already in use to a limited extent, being used, for example, to record surgical operations, for teaching, and demonstration purposes. The cost of the viewing spectacles is, however, too high for there to be any immediate likelihood of the system being adopted by the commercial film industry, and until a system is perfected which asks nothing of the observer in the way of his using special viewing devices, the stereoscopic film will probably remain little more than a curiosity to film fans.

One method that enables viewing analysers to be dispensed with is known as the Parallax Stereogram system. In this system a large diameter concave mirror is used to form an image on a transparent ridged screen, which in turn is imaged on a photo film. This device results in multiple strip pictures which, when projected upon a translucent convex-ridged screen, exhibits stereo relief, the eyes of the observer each seeing a different strip image. In the form of still transparencies this system has been applied to the making of advertising signs, but the problems confronting its successful translation to the cinema screen are so formidable, and the practical limitations are so severe, that the application of such 'critical angle' systems to the commercial motion picture is a long way off.

CHAPTER IX

CARTOONS AND TRICK-WORK

THE animated cartoon predates the invention of the cine-film, for the moving figures of the zoetrope were the ancestors of Donald Duck.

The very earliest moving pictures were drawn by hand, and the observer looked at the drawings themselves in such instruments as the Zoetrope. The modern cartoon film, whose educational, scientific, and entertainment value is now firmly established, consists, however, of photographs of drawings. In the early forms of film cartoon (the first of which was made in England in 1904) pen-and-ink drawings were made on white paper whose edges were punched with holes fitting over register pins on the artist's desk and on the camera copyboard. There are some 10,000 separate frames in a cartoon lasting ten minutes on the screen, and in the early forms of animated cartoon a separate drawing was made for every two frames of film. Even although the greater part of each drawing was a tracing, this method of working was exceedingly laborious, and various attempts were made to simplify the process. One more or less successful expedient which is still used successfully by amateur cartoonists was to employ cut-out figures of the cartoon characters with jointed heads, limbs, and features. These were laid down over the drawn background, and a frame of film exposed. The various movable parts of the cut-out were then moved in the required directions, a distance of approximately 1/8th of an inch, and the new position photographed on the neighbouring frame. Working this way, however, it might take several hours to record a figure walking from one side of the screen to the other, and the technique used for modern cartoon film production has travelled far from its primitive beginnings.

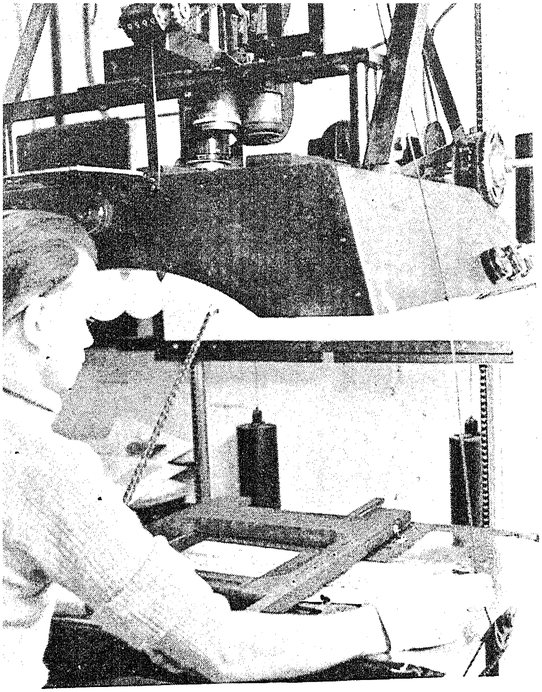
In 1923 Walt Disney hawked his first cartoons round Hollywood trying to find a purchaser. Eleven years later he made the first colour cartoon using the Technicolor

process, and it is largely due to Disney's foresight and genius that the entertainment cartoon is now an established feature of nearly every cinema programme. It is interesting to note, however, that despite the world-wide popularity of Disney's work, the cost of making modern cartoon films is so high that the profit on them is small, and until the staggering success of his first feature-length cartoon, Disney's organization relied for its profit on revenue from sales of the rights to use his cartoon characters in advertisements and as toys and dolls.

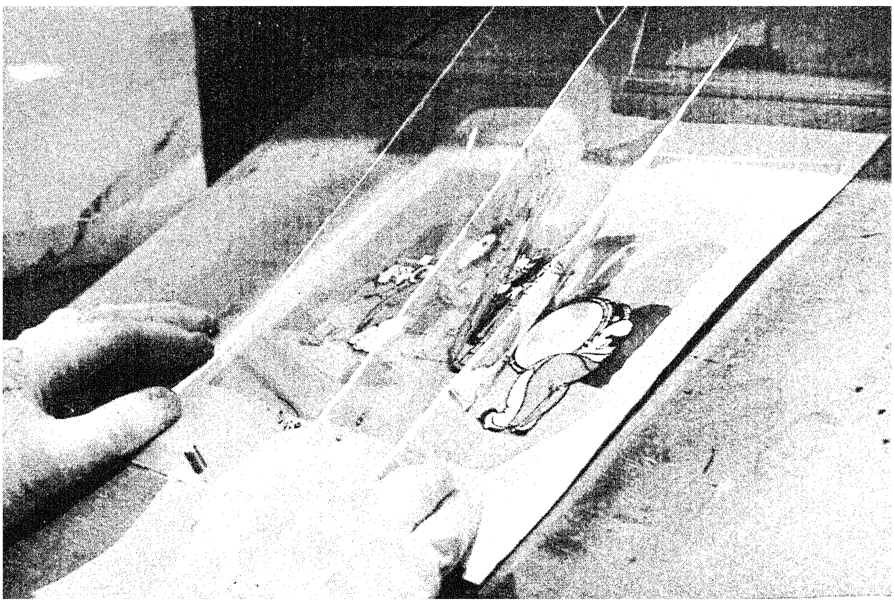
Present-day cartoons rely very largely on drawings made upon transparent celluloid sheets which are laid over a drawing of the background. A single, elaborate background drawing can thus be used for a complete scene (sequence). Moreover, the individual characters may each be drawn upon a separate sheet of celluloid, and as many as half a dozen sheets may be required to build up each picture before it is photographed. In this way it is possible to limit the labour of drawing merely to the redrawing of the moving parts of the design only. Moreover, in regularly repeated movements such as those performed by legs in walking, it is possible to use a cycle of drawings of the moving limbs, say half a dozen in number, repeatedly. There is, however, a limit to the number of superposed celluloids that can be used. If the pile is more than 0·04 inch thick, the shadows of the top drawings will be detectable on the bottom layer. If, however, the elements of a scene are separated into several planes, painted on glass, and set up at different distances in front of the camera, not only can this difficulty be overcome by lighting each plane and its appropriate celluloid sheets independently, but the effectiveness of cartoons is greatly enhanced, for an illusion of depth is introduced into the picture which it would be difficult to create when the drawings are confined to a single plane. Because of the separation of scene elements, the possibilities of special effects are greatly increased. Thus, since the cartoon characters are on transparent backgrounds, it is possible to introduce such effects as the glow around lamps, sparkles,

sunsets through dark clouds, ripples, shimmer and heat haze. Moreover, gradual changes of light level or colour, which would be difficult to paint, can now be carried out relatively easily. A further step was to make the background a miniature setting in front of which is mounted a frame into which the celluloid sheets can be slipped in turn; and finally, to combine a three-dimensional background setting with a multiplane foreground. The multiplane camera used by Disney is mounted to shoot vertically downwards from the top of a chassis carrying several planes on which action is depicted. The camera photographs through these elements, which are painted on glass, the animated characters being painted on celluloid sheets held in register on one or more of these levels.

The making of a modern sound-and-colour cartoon proceeds somewhat along the following lines. The scenario of the story is first plotted out in complete detail. Then the musical and spoken score are recorded. The tempo of the music is recorded by a signal light operated by the beating of the conductor's foot, and the mouth movements of living actors are filmed as they record the speaking and singing parts. These photographs show the exact number of frames covered by each syllable or note, and are merely used as a guide to the artist responsible for drawing the mouth movements of the characters. The chief artist now prepares a series of key drawings of the characters, most of which are rough sketches, with a finished drawing whenever expression, &c., is important. The so-called 'in-between artists' now supply the required number of sketches to link up the key drawings. These paper drawings are then handed over to experienced girl tracers who make exact drawings on celluloid—perhaps 10,000 or so. If the film is to be in colour, the figures on these celluloids are painted in with opaque colours. Meanwhile a series of scenes have been painted to serve as a background to the characters, and as each sequence of drawings and backgrounds is completed it is handed over to the cameraman for filming. Owing to the large depth of

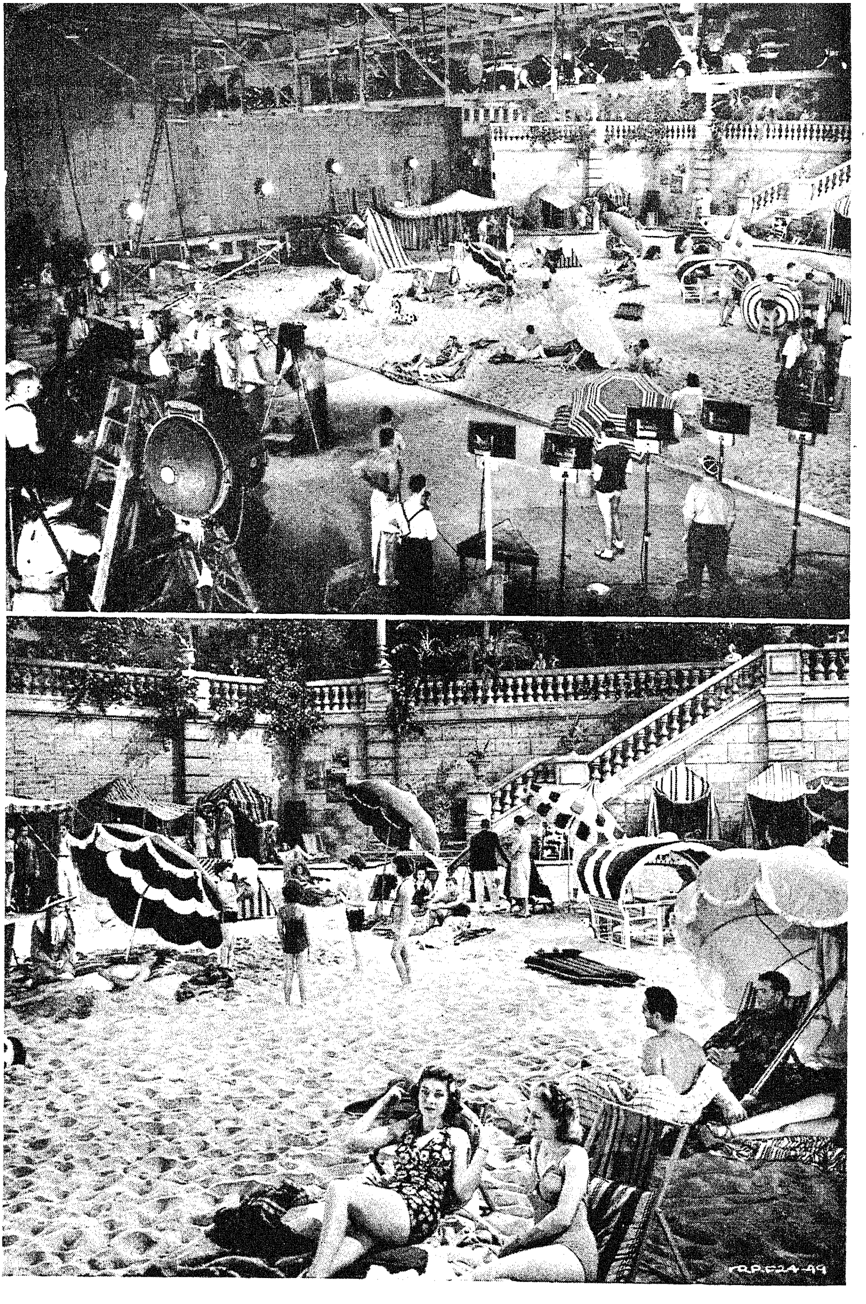


Making a Cartoon Film: A touch of the cord takes one picture on a cartoon camera



Making a Cartoon Film: Building up the frame with a number of celluloid sheets

By courtesy of Publicity Picture Productions, Ltd.



The beach scene in the lower picture was staged in the studio seen above. It involved importing, among other things, a hundred and twenty tons of sand. Note that the windows of the 'hotel' in the background are in fact small scale models

From the film 'Topper Takes a Trip', by courtesy of Hal Roach Studios

field necessary in the multiplane camera, an aperture of f 32 is frequently used and the individual exposure times vary from 1 to 10 seconds. As many as six operators are necessary during the recording, their work being co-ordinated by placing each operator in charge of one plane which he manipulates according to predetermined instructions extracted from a master control sheet. Moreover, the particular frame being exposed is indicated mechanically on each instruction sheet by glass pointers driven by the camera mechanism. When making a colour cartoon, three separate negatives must be made for each frame. Each of these negatives records one of the three primary colours as explained on page 100. The three exposures are made in succession on the same film, the filters changing automatically at each exposure. The resulting negative is printed in a special printer which, by skipping two frames and printing every third, collects the three separation records on to three separate positive films. From these prints, the imbibition matrices required for Technicolor printing are obtained (see p. 106). Incidentally, it is interesting to note that, given his efficient black-and-white technique, the making of the first three-colour cartoon by Disney was a considerably easier job than the making of the first three-colour films of natural subjects, and the early Silly Symphonies were probably the first films to be made in which the colour was under the complete control of the producer. Moreover, apart from the novelty of a colour cartoon as such, the fact that a complete range of colours was, for the first time, seen on the commercial screen in the form of a coloured cartoon was an important factor in the immediate popularity of such cartoons. Apart from its established position as an entertainment, the cartoon film in the form of animated diagrams is proving of increased value in education; but we deal with this aspect in Chapter XI

Trick-Work

Trick cinematography has been employed to a considerable extent since the earliest days of the film's

commercial history. The early forms of tricks were introduced at the time of shooting the scene by suitable manipulation of the camera. Some of these tricks are immediately obvious as such to the audience, as when a scene which has been photographed at below normal speed is projected at the usual rate with a comical speeding up of action, while magical transformations of the scenery, appearance and disappearance of characters in it, and so on, can be obtained by stopping the camera at a given moment and then restarting it when the required alterations have been carried out. An elementary trick with which most amateur cinematographers are familiar is to film a scene with the camera held upside down. When such a shot is spliced into the film so that the action is the right way up it will also be seen to be proceeding backwards. In such scenes divers appear to make miraculous leaps from the water to the springboard, houses build themselves up unaided from their ruins, and so on, and it is obvious that the action was filmed backwards.

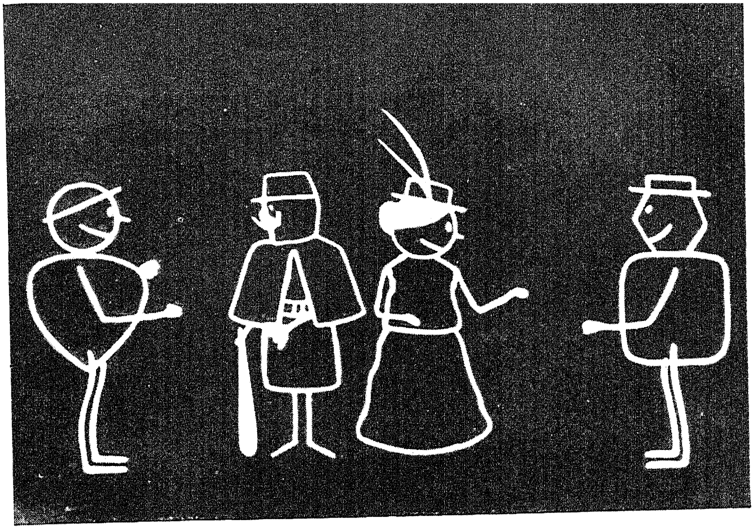
In Wells's film *The Invisible Man*, however, it is not at first obvious that the running footsteps which appeared one by one in the snow as the 'invisible man' ran across the scene were recorded by a similar technique. Suitable footsteps having been made, the camera was run backwards and stopped every few frames so that the prints could be obliterated one by one. Incidentally, the technique of stopping the camera while adjustments are made to the scenery is a simple way of animating models. The prehistoric monsters appearing in such films as *King Kong* are, for example, frequently made of plasticine, and the action is exposed frame by frame, the position of the limbs, &c., being altered slightly between each exposure along the lines described on p. 126.

Another curious effect which must obviously be a trick is that in which a character appears to be acting with himself. Such scenes can be made by placing a vertical mask in the camera gate and so preventing light from reaching, say, the right-hand half of the frames.

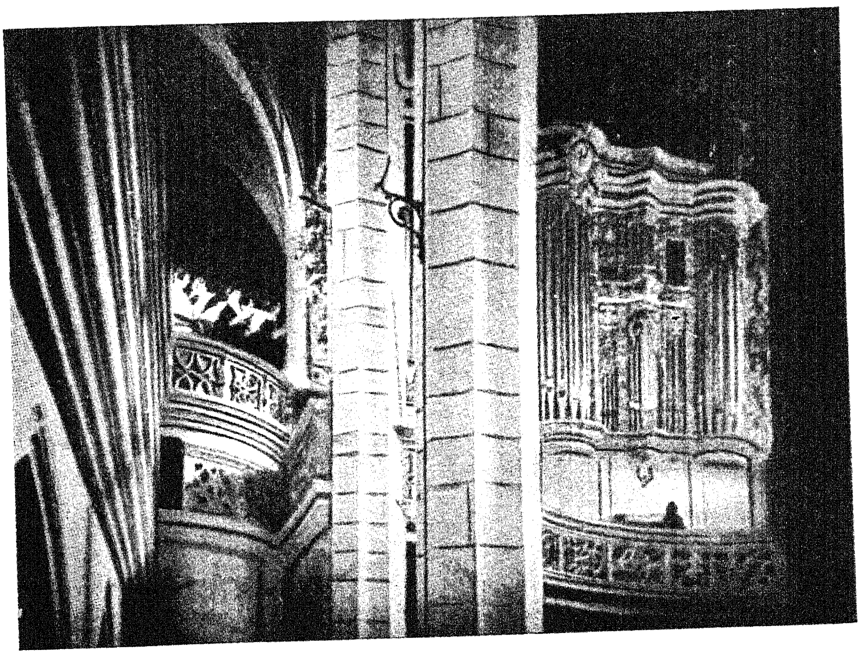
The scene is photographed, the actor being careful not to move into that part of the scene which is not being recorded. The film is then passed through the gate a second time, but on this occasion the mask is moved over to protect the area that has already been exposed, and the actor confines his movements to the other half of the scene. In order that the dividing line between the two separate photographs shall not be visible on the screen, it is usual to arrange that this line shall follow some fairly well-defined vertical in the scenery, such as a door jamb. In another form of double exposure used to obtain 'ghost 'effects, masks are not used. Of the two exposures made on the film, the first is of the scene itself and its 'solid' actors, while the second is of the 'ghost'—an actor who performs against a dead black background. In effect, therefore, only the 'ghost' is photographed when the film travels through the camera gate for the second time, and the details of the background scenery will be seen through its 'body'. An alternative to making two separate exposures on the same film to produce such effects is to roll up a film of the ghost face to face with a piece of unexposed negative film. The pair of films is then threaded through the camera gate with the print towards the lens, and consequently, when the scene is filmed, the light entering the lens prints the ghost on to the negative film at the same time.

The above are the basic methods by which practically all trick effects are obtained, but nowadays they are rarely carried out at the time of shooting, since, for convenience, speed, and efficiency, it is simpler to introduce them during the processing operations. Moreover, as will later become obvious, it is nowadays of vital importance to the success of a film that the large percentage of trick-work which it contains shall not be detectable as such, and every film-producing organization accordingly possesses a completely equipped laboratory containing expensive and complicated equipment for making every conceivable variant of the basic effects mentioned, in such a competent

manner that we do not suspect the presence of a trick at all when we see the film on the screen. It is necessary to emphasize the tremendous difference between the magic-working trick cameraman of a few years ago and the special effects engineer of to-day whose object is to save his company money rather than puzzle the audience, and whose one excuse for existing is that he makes it possible to screen scenes that would otherwise be impossible, impracticable, dangerous, or too expensive to produce commercially. One way of saving money is to use models in place of such expensive properties as aeroplanes which are to crash or motor-cars which are to fall over cliffs. As an example from a recent film, a realistic sea-fight between seventeenth-century galleons recorded at sea by straightforward camera methods would have cost far more than the budget available for filming the entire production. The same sea-fight recorded by means of miniature vessels manœuvred in a tank of water, besides being relatively inexpensive, was made in a fraction of the time that would otherwise have been required, and, moreover, its cost was known to within a pound or so before production of the film commenced. In order to convey an illusion of reality, every detail in a miniature must be right, for it will be magnified many times on the screen, and miniatures are, therefore, not necessarily toy size (see Plate 14). It was both cheaper and easier to make the miniature galleons referred to 12 feet long with masts 16 feet high, and moreover, it was then possible for each galleon to carry a man concealed in the hull to manipulate the necessary mechanical devices. There are several methods by which the film of this miniature sea-fight might have been combined with one of living actors without the cinema audience suspecting that the two films were made on different occasions and on a different scale of magnification. The most obvious way has proved in practice the most difficult to perfect and is called 'rear projection'. The actors perform in front of a large translucent screen perhaps 20 feet by 15 feet, made of sand-blasted glass or matt celluloid, on which



From *Drame chez les Fantoches*, a cartoon by Emil Kohl (1908), one of the earliest animated drawing films *By courtesy of the National Film Library*

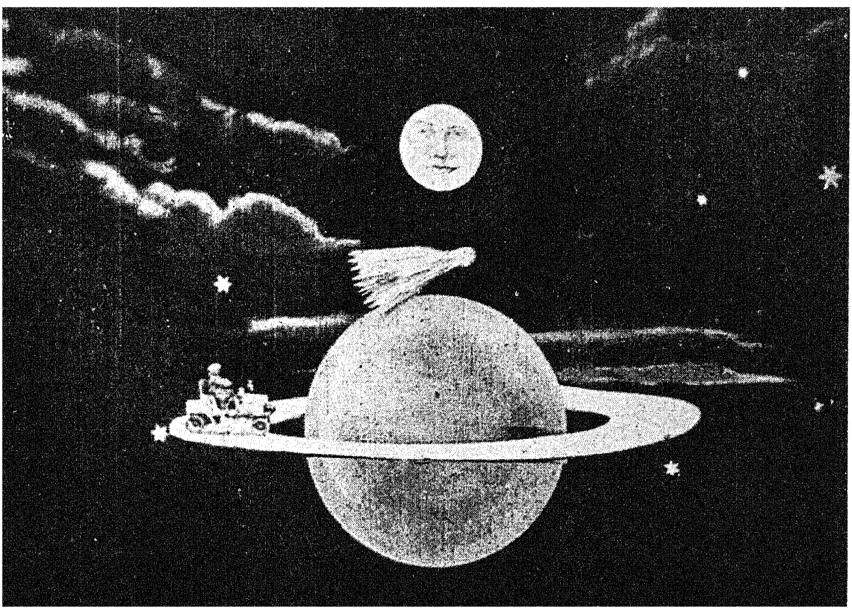


An unusual shot of a Cathedral Choir in which the Schufftan Process has been used

A photograph of the actual cathedral was made and reflected into a mirror, and at the parts where the choir and organist are seen the mirror was scraped away and two platforms were built at a distance behind the mirror to take them, thus filling the spaces. (See diagrams on pages 134–135) *By courtesy of Edward Carrick, F.R.S.A.*

From 'Rescued by Rover', produced in 1904 by Cecil Hepworth. The cast consisted of Mr. and Mrs. Hepworth, their baby son, Mr. and Mrs. Sebastian Smith, and Rover the dog

By courtesy of Cecil Hepworth



From 'The Motorist', a trick film produced in 1903 by Mr. R. W. Paul, pioneer British designer of apparatus and producer of films *By courtesy of the National Film Library*

is projected from the rear the film which is to form the background (Fig. 32). The cinema camera, in photographing the actors, re-records the background film and, in the combined result, the actors appear to be performing in the surroundings where the background film was made. The motor driving the projector and the one which drives the camera are electrically synchronized so that the shutters of the two instruments are always open at the same moment and, since any trace

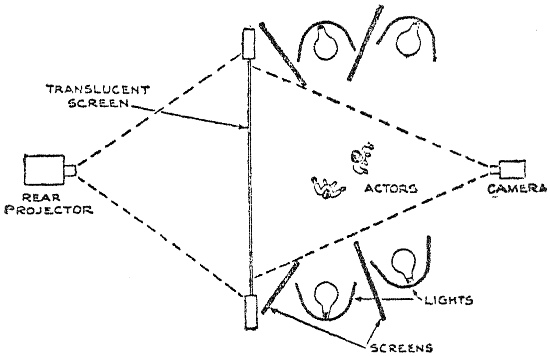


FIG. 32. Top view of Studio Lay-out for back projection.

of unsteadiness in the projected picture will, of course, destroy the whole illusion, the highest attainable accuracy must be maintained throughout every stage from background camera, through the printer, projector, and composite taking camera. Moreover, in order to obtain an illusion of reality with models, it is essential to maintain correct perspective between the models and the living actors and, in the case of moving shots, to scale down the rate of movement. Thus, if the ship seen on the screen to be battling with waves was, in fact, a model floating in a tank, the wavelets on the water surface must be slowed down very considerably if they are not to appear unnaturally fast when seen on the cinema screen. This is readily accomplished by photographing such scenes with high-speed (slow-motion) cameras.

The extent to which the rear projection process is now used is surprising. Over 80 per cent. of the film

Captains Courageous was filmed in this way, and, although the film was a sea story, the whole of the action was recorded in the studio. Most of the fantastic buildings in H. G. Wells's film *Things to Come* were background projections from films of miniature settings, although some of the settings were 50 feet in length.

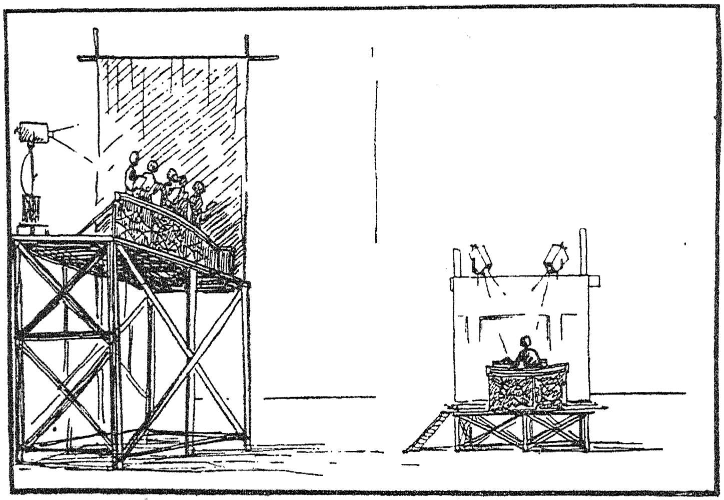


FIG. 33. All that was actually built for the Cathedral Choir set shown in Plate 15.

Nevertheless, the scope of the process is sometimes limited by the fact that the background image will only be clearly visible when the rear projection screen is kept in comparative darkness, and it must, therefore, be shielded from the lights that are used to illuminate the actors in front of it.

In the Schüfftan system the background is introduced in a different manner. Immediately in front of the camera lens is placed a mirror at 45 degrees, whose silvered surface reflects into the lens either a still photograph or a cine-film which is projected on its surface from the side. A portion of the silvered surface is removed, and through the window so formed the camera photographs action taking place in front of the lens. The resulting negative, therefore, records over parts

of its surface the image projected on to the mirror from the side and over the remainder the subjects in front of the camera. In a typical Schufftan negative the top half of each picture will consist of the scenery so projected from the side of the camera, and the bottom half of action taking place in front of it, the junction between

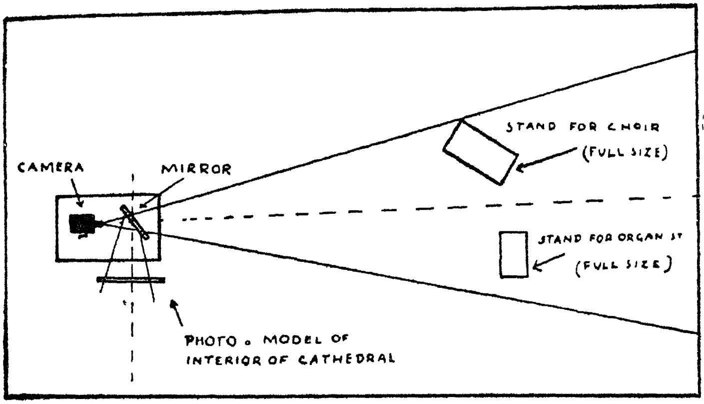


FIG. 34. Plan showing position of camera, mirror, photograph and platforms for Cathedral Choir set.

the two being cunningly chosen to coincide with those convenient outlines or shadows where its presence will be least noticeable (see Figs. 33 and 34 and Plate 15).

Another highly ingenious method of multiple image photography—the Dunning process—can only be properly understood by readers having a knowledge of the properties of colour filters.

In this system a film of the scenery in which it is required that the acting is to appear to take place is toned a transparent yellow and is threaded into the camera in front of a panchromatic negative film. The actors are lit with yellow light and perform in front of a brilliantly lit purple-blue background. Wherever yellow light is reflected from the actors it passes unhindered through the transparent yellow printing mask and records as an image of the actors on the panchromatic film. Wherever the blue light from the background meets the yellow image in the camera gate it is absorbed,

since blue is complementary to yellow, and as a result, so far as the blue light is concerned, the yellow image acts as an ordinary black silver image would in that it stops light in proportion to its density at any point, and a print of the yellow image, therefore, records on the rear film wherever the blue light falls. As the actors move in front of the blue background they prevent blue light from reaching the films, and so prevent the 'scenery' film from printing, their own yellow-lit figures recording in its place.

It frequently happens, however, that the most economical way of combining scenes together is during the printing process, and various pieces of specialized apparatus are used for this purpose.

The Animation Stand

One useful piece of apparatus is an animation or vertical title stand. A cine-camera is mounted vertically and is focused on an opal glass table-top illuminated from below. If one half of this table is masked the 'split-screen' effect can be introduced by loading the camera with a 'bipack' consisting of unexposed negative film and a print recording the action which is to appear on the left-hand side of the picture. A second print is then substituted recording the action on the right-hand side, the mask over the printing window being moved over and the film run through the camera again.

The more curious of the transitional effects known as 'wipes', wherein one scene blends into another by movement rather than by cross-fading, are carried out on the animation stand. A typical wipe takes place over 2 feet of film and requires thirty-two pairs of matched masks Each pair has an open space which exactly matches the opaque area in its mate, and the disposition of the open spaces over the area of the frame in any pair differs slightly from that of the preceding pair. The film on which the wipe is to be recorded is run through the camera twice. On the first occasion it is in contact with a print of one of the component scenes and the exposures are made through one of the sets of masks.

The film then travels through the camera face to face with a print of the second scene, and the second set of masks is used when exposing (see Fig. 35). This method of making wipes is, however, tedious, and is used only in the more complicated forms of wipes of which over 300 varieties have been listed. The simple form in which the scene is wiped off sideways is more easily carried out by the use of a moving shutter-mask which forms part of the optical system of the apparatus known as the optical printer.

Optical Printing

Optical printing, or projection printing, as it is sometimes called, is a process of rephotographing one film upon another. Essentially, the apparatus used is a cine-camera fitted with a registration movement and focused on the film to be copied as this travels through a printer head, likewise equipped with a registering movement. The two units are rigidly mounted facing each other on an optically worked metal bed, and can be driven in synchronism forwards or in reverse. The fact that, in this system of printing, the negative and positive films are travelling through different machines instead of in the closest possible contact enables many exceedingly valuable manipulations to be carried out, and a considerable proportion of trick photography is made on printers of this type. Practically every feature film utilizes the services of the optical printer to some extent. Suppose, for example, that when a particular scene has been photographed it is found that it would have been better had it been a close-up. It is only necessary so to arrange the relative positions of the camera and the gate through which the film is travelling that the chosen portion of the image is suitably enlarged so as to fill the frame in the camera gate. Indeed, if desired, the transition from long shot to close-up can be carried out while the film is travelling through the printer, and so give an effect similar to that obtained by the Zoom lens (p. 27). Then again, by gently rocking the camera of the optical printer, a slight movement can be introduced into studio

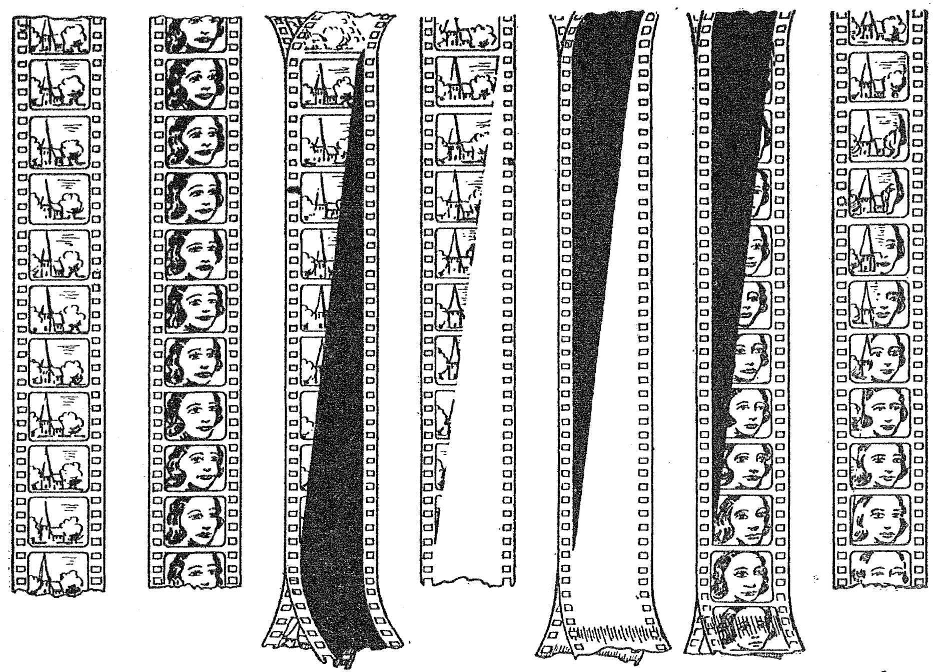


FIG. 35.

(1 and 1*a*) Two scenes which are to be connected by a wipe. (2) An opaque mask, in contact either with the negative or in front of the unexposed film, results in only a portion of the first negative printing on the film. (3) Positive film with mask removed showing where the first image is situated. (4) A second mask now protects the exposed area. (5) The second negative is then printed on to the same film, but can only record on the unmasked portion. (6) When the exposed film is developed the wipe results.

scenes of boat, aeroplane, and motor-car interiors which adds to their 'natural appearance'. Such effects as fades, dissolves, split screen, double exposures, and composite scenes are nowadays nearly always made on the printer, as are those wipes whereby one scene rolls, glides, twists, or smears into the next.

To make a wipe on the optical printer, either the mechanical shutter mentioned above is employed, or film masks which travel with the film and are called 'mattes' are used, of which those shown in Fig. 35 are typical. One such mask is loaded in contact with scene 1 and the other with scene 1*a*. The two bipacks are then projected in turn on to the same negative. An important development of this technique materially simplifies the problem of background scenery in that it enables films made on different occasions to be combined undetectably on to one positive. Suppose, for example, that one scene in a film requires a highly salaried actor to walk through a tropical jungle, and that, during the brief time the actor is on the company's payroll, the necessary film of the forest background is not available for the rear projection process to be employed, the actor will then perform his part in front of a dead black curtain. A print will be made of this film; this will first be slightly reduced in order to remove all traces of fog, and then greatly intensified so that the image of the actor becomes a black silhouette on a completely transparent background. A positive print is then made from this silhouette in which the area occupied by the actor's body will be clear film and the surrounding background opaque. When the forest film is eventually obtained these two mattes are used as masks through which in the first case the background shot and in the second case the action shot are double printed on to a single film in which the actor will appear to be performing against the forest background (Fig. 36).

This is, of course, a laborious procedure only really justified in such elaborate trick films as *Topper*, where this technique, the split-screen effects mentioned earlier, and on occasion the use of invisibly thin wires to

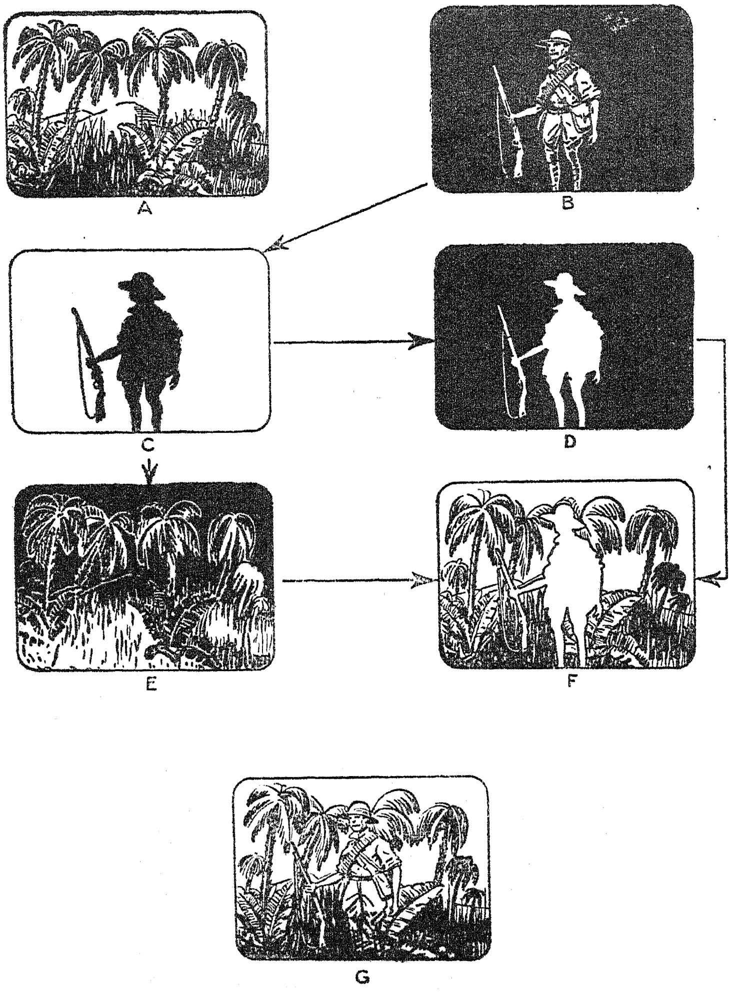
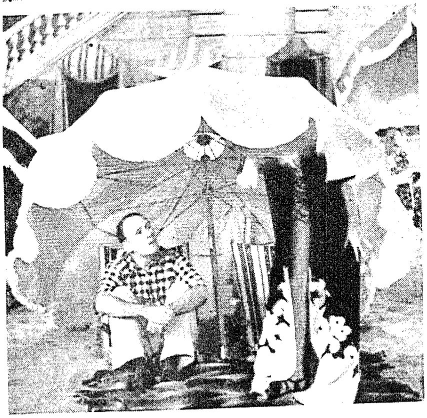


FIG. 36.

A. Background to be inserted.
B. Actor performing against black background.
C. Heavily intensified negative of scene B.
D. Print from C in which actor is transparent.
E. Film C is superposed on negative of scene A.
F. Resulting positive record on printing composite E.
G. Print D is placed over F and protects background while normal negative of scene B is printed into the unexposed areas resulting in required composite print.





An effect produced by means of an animated travelling matte in the optical printer. The method which may have been employed in this case is shown diagrammatically in Fig. 36, page 140. In this case, however, in succeeding frames of the negative of Miss Bennett, more and more of her body would be removed by chemical reducers before the matte is made as described in the text

From the film 'Topper Takes a Trip', reproduced by courtesy of Hal Roach Studios

An elaboration of the 'Ghost' technique described on page 131. In this scene the champagne bottle was supported by invisible wires as it moved about the set. At the point where the ghost is to materialize, the shutter aperture was gradually closed down while Roland Young remained absolutely motionless. The film was then wound back and Miss Bennett stepped into the scene, which was then re-shot with a gradually increasing shutter aperture.

The rate of closing and opening the shutter was identical so that in the composite image obtained everything except the ghost received its normal exposure. If Mr. Young had moved during these operations his image would have been doubled. This difficulty could have been avoided, if necessary, by combining the 'ghost' technique with the 'split screen' technique described on pages 130 and 141

From the film 'Topper takes a Trip', reproduced by courtesy of Hal Roach Studios

move objects about the set were exploited to the full. Simple composites are usually made on the studio floor by rear projection. Even so, the result can often be considerably improved by further treatment of the composite negative in the optical printer. Suppose, for example, that owing to the difficulty of adjusting the studio lights suitably without ruining the image on the rear projection screen, there is an unfortunate shadow on one of the actors; a suitable mask in the optical printer may lighten the shadow, portions of the background which appear unnaturally light can be 'printed in', and so on. This salvaging of otherwise spoilt scenes is on occasions of first importance. A typical example which saved the R.K.O. film company hundreds of pounds for a retake was as follows: In a scene in a war film an aeroplane crashes and is supposed to burst into flames just as the pilot climbs from the cockpit. It so happened, however, that the plane did not flare up until the pilot had actually reached the ground and crawled out of the scene. In such circumstances it would not have mattered if the flames did not come until some hours later for, of course, the camera could have remained focused on it and no further film exposed until it had been set on fire. Such a shot was not, therefore, thrilling enough. Accordingly, on the optical printer the split-screen technique was used, all the scene except that immediately surrounding the pilot being masked off. In the second printing this surround was printed with the negative actually photographed some minutes later, namely, at the point where it burst into flame, and the final effect on the screen was, therefore, that which the producer had originally intended. On another occasion, after an important scene which was supposed to be in Russia had been shot, it was found that one of the moving railway trucks which formed the background had English wording on it. By means of a grease pencil mark placed on a glass plate in front of the optical printer aperture, the wording was slightly blurred and no longer readable. The glass was slid along frame by frame to match the movement of the truck. Less elaborate

masks are frequently used to introduce shadows or subdue the highlights on to the scenery of a stationary shot, and even to modify its lighting by, for example, shading back the top of the frame or rendering the background behind the actors a darker tone than would otherwise be the case. Many of these effects demand the making of an intermediate negative, and absolutely first-class processing and operating technique is essential if the final product from the optical printer is to slip unnoticeably into the production.

CHAPTER X

SUB-STANDARD APPARATUS

As was mentioned in Chapter I, the size of the standard film used in picture theatres throughout the world dates back to Edison's experiments in the early nineties.

The actual size of the film (it is 35 mm. wide) can be seen in Fig. 37. Naturally a size of film which is large enough to produce pictures on a theatre screen 20 or 30 feet wide is needlessly large for producing pictures 2 or 3 feet wide in the home or classroom, or even 10 or 12 feet wide in assembly halls. For these uses, which are generally described under the inclusive term 'non-theatrical', a number of film sizes narrower than 35 mm. are manufactured. The principal 'sub-standard' sizes, as they are called, are also shown in Fig. 37.

The 16-mm. size was introduced by the Kodak Company in 1923, and is now in general use among the more ambitious amateur photographers and home-projectionists, and among scientists, business men, and teachers. About five years ago it was found feasible to add a sound-track to 16-mm. film by abolishing the perforations down one side (Fig. 37), and the gulf between home projection and professional projection, which was growing wider as the era of silent films receded, was bridged. The 9·5-mm. size was introduced by the Pathé Company in 1921, and is now in general use among amateur photographers who must consider first costs, and among home-projection enthusiasts for whom the Pathéscope Library caters generously. In 1937 this gauge, too, added its sound-track, though, as there were no side perforations to abolish, a drastic reduction in the size of the picture on the film was involved.

The 8-mm. size was introduced by the Kodak Company in 1933. In spite of the minute picture carried, the technical possibilities of 8 mm. both in black-and-white and colour are remarkable. One limitation inherent in the use of such small film is that inability to

decipher each picture with the naked eye adds somewhat to the difficulties of editing. The circulation of films on this gauge, and indeed also on the 9·5-mm. gauge, among institutions of various kinds usually requires that a projector sufficiently powerful for large-

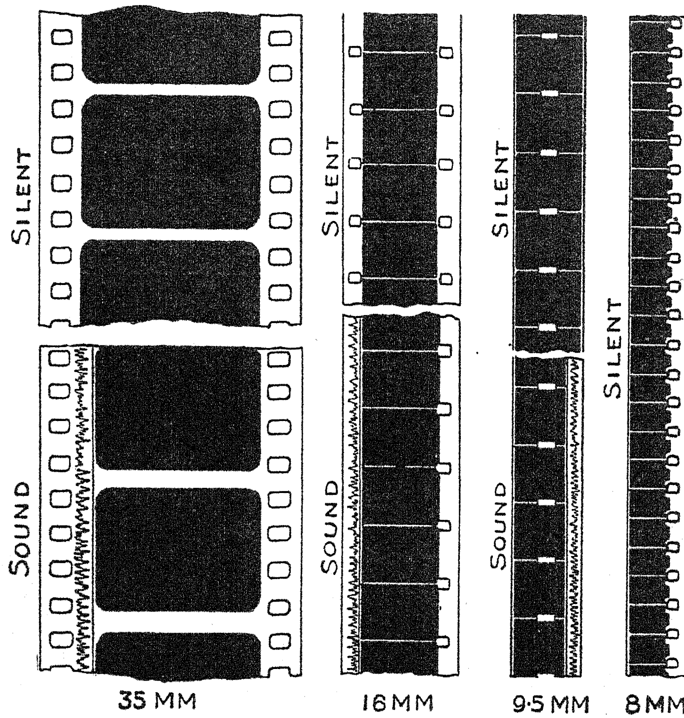
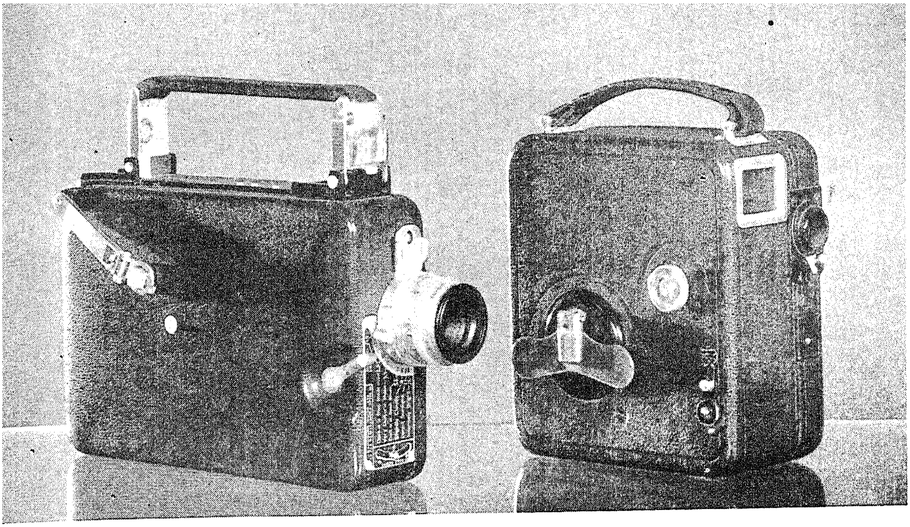


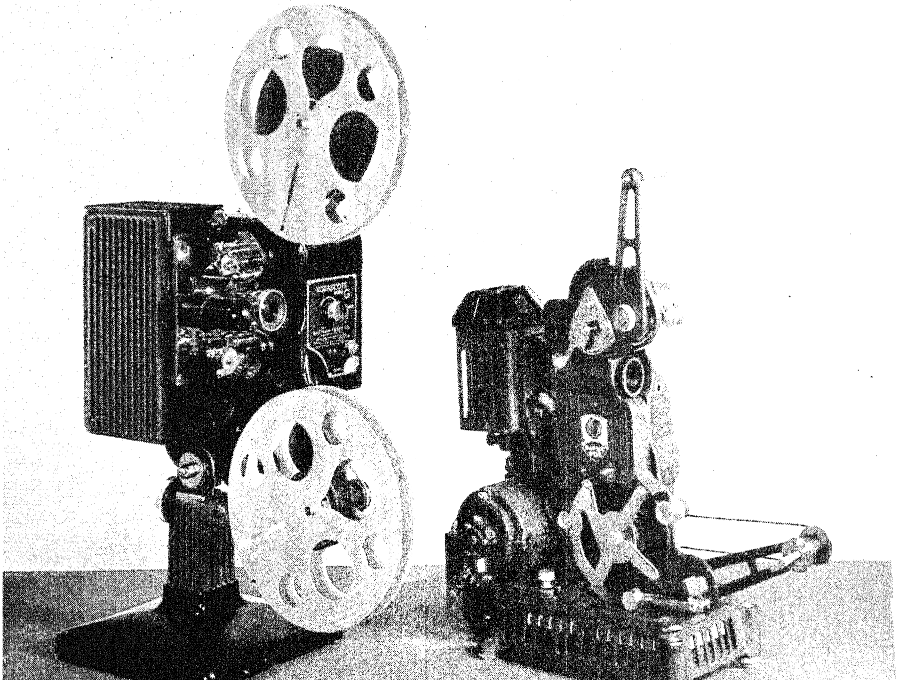
FIG. 37. Standard and Sub-standard Film (actual size).

scale use should be available for loan along with the film, as it will generally be found that the existing equipment, if there is any, is for 16-mm. film only.

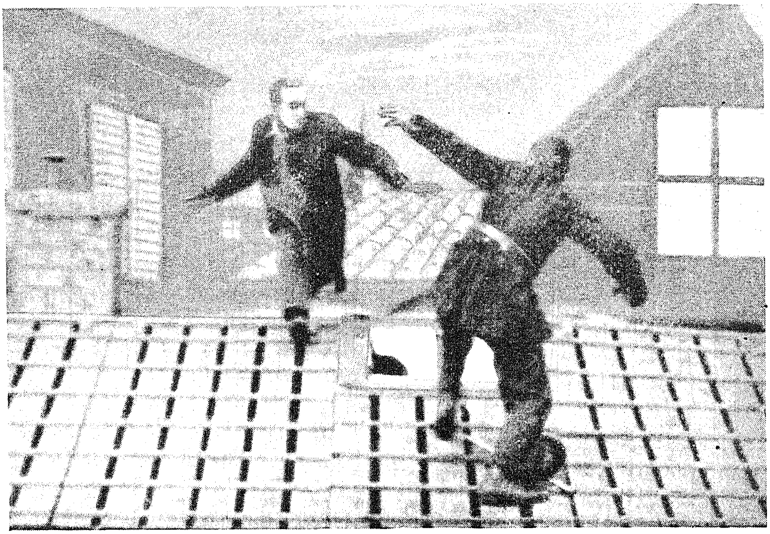
The advantages of the sub-standard film by no means stop short at the lower cost of film stock and the convenience of the camera, which can be slipped into a pocket or handbag, and the projector, which can stand on the drawing-room table. Freedom from fire risks is a matter of more fundamental importance than all the other considerations. For home projection it is essential



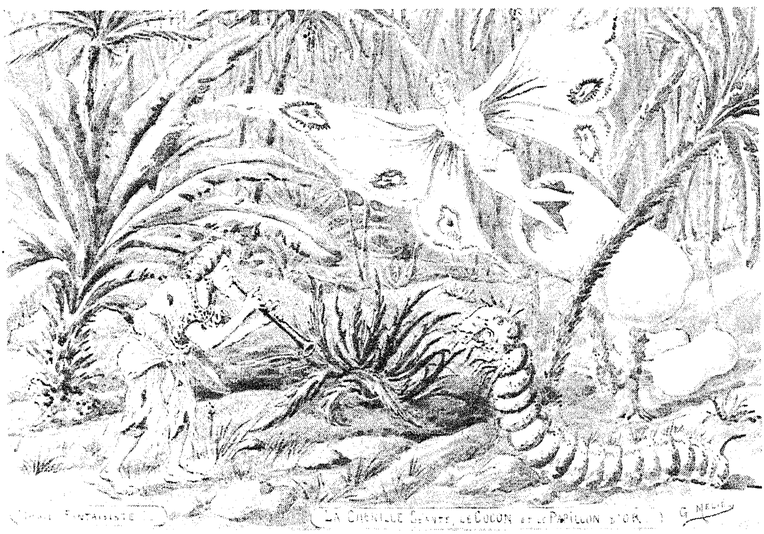
Left: 16 mm. Magazine Cine-Kodak Camera
Right: 9·5 mm. Pathé Camera



Left: 16 mm. Kodascope and (*right*) 9·5 mm. Pathé Projector



From the 'Life of Charles Peace', produced by the Sheffield Photo Co., 1903, one of the earliest one-reel story films to be produced in Great Britain
By courtesy of the National Film Library



Mélie's original drawing for the film, 'The Brahmin and the Butterfly' (*circa* 1903)
By courtesy of A. Cavalcanti

that the film should be of the kind described as 'safety' or 'non-flam', which is manufactured from cellulose acetate. Sub-standard film is always of this kind, and therefore the use of a sub-standard projector absolutely eliminates fire risk. The cheap toy projectors sometimes imported into this country which take short lengths of 35-mm. film certainly never see the inside of any prudently conducted home. On the other hand, the popularity of sub-standard cameras and projectors has increased year by year, and it is now estimated that the possessors of such apparatus in Great Britain must be nearly 200,000 in number.

Continental and American exporters vie with one another, and with British manufacturers, for the enjoyment of this extensive market, and in consequence the would-be recruit to the army of amateurs is apt to be bewildered by the diversity of designs displayed before him by the would-be salesman.

It may, therefore, be of interest to some of our readers if we review briefly the considerations which will weigh with the wise purchaser of cinema apparatus. We will assume that the problem of which film-width to choose has already been settled in accordance with the indications of expense and scope which we have already outlined. The decision made is only a first step towards a final solution of the question, as each film-width comprises numerous alternatives in design. We will consider the camera first, and proceed straight to its most important component—the lens.

Two main differences in camera design affect the lens. Firstly, does the lens mount permit focusing adjustments, and secondly, does it permit changes from one lens to another? A fixed lens enjoys the advantages of cheapness and ease of manipulation. It is impossible to use the fixed-focus method with any lens which has a very wide aperture or a long focal length, and this method is accordingly unsuitable for working in poor lights or obtaining close-up views. It is, however, possible to take close-ups, especially for titling, with a fixed lens by using a supplementary lens with it.

The possibilities which are opened up by possessing a choice of lenses include, of course, getting more in the picture by means of a special short-focus lens, and making distant objects look larger by means of a long-focus lens. The normal focal length for a 16-mm. camera lens is 1 inch. A $\frac{3}{4}$-inch lens may be useful in a confined space where it is otherwise impossible to get sufficiently far off, and a 2-inch lens will be required for sports photography of a simple kind, or for street-scene photography when it is desirable to avoid drawing the attention of one's subjects to the fact that they are being photographed. The naturalist will inevitably require a lens of at least 3 inches, and may on occasion be glad if he has available a 4-inch, 5-inch, or even a 6-inch lens.

The longer the focal length of the lens the harder it becomes to get a clear picture without the use of a tripod. In general it will be found expedient to resist the temptation to use a focal length longer than 2 inches with an unsupported camera.

There is a tendency among buyers of sub-standard apparatus to succumb to aperture snobbery, and assume that the possession of an expensive wide-aperture lens will solve all their technical problems. Actually, of course, the only use of a wide-aperture lens is for taking in a bad light or at a high speed. It has to be borne in mind that a wide-aperture lens of, say, f 1·4 will almost certainly be compounded of more component glasses than a lens of maximum aperture f 3·5. Accordingly, as each component adds its quota of 'flare' due to internal reflection, the f 1·4 lens stopped down to f 3·5 may not give as good an image as the f 3·5 lens at full aperture. Many of the early entertainment films taken with lenses of maximum aperture f 4·5 showed first class definition.

An important refinement which the purchaser of a sub-standard camera will find offered to him is a range of different speeds.

Normal speed is, of course, 16 pictures a second. The alternative speeds which may be offered are one picture at a time, and 8, 24, 32, or 64 pictures a second. The single-picture setting is, of course, intended for

trick titling and cartooning, and the half-speed setting may be used for the same purpose, as a practised hand can work the release for a single exposure when the camera is running at half speed.

The 24-a-second setting is useful for films to which a sound-track is to be added later, as this is the correct speed for projecting sound-film. Thirty-two and 64 give effects of moderately slow motion, or may be used for counteracting the vibration when taking from a car or train.

Sub-standard cameras fall into two classes according to their method of loading. One class carries film wound on spools with solid sides. Such spools can be loaded in daylight and unloaded again in daylight when they are finished, but between these two stages the camera must be kept closed; one cannot substitute one half-finished spool for another, and therefore once the photographer has put in a spool of colour film or extra-fast film, he has to continue with it till it is finished, even if the subjects which next present themselves give no special scope for colour or speed.

The other class of camera known as 'cassette-loading' meets the difficulty by including both exposed and unexposed film in a single light-proof container, from the middle of which a loop protrudes for passage through the camera gate.

With such a device, changes in the type of film used can be made at any moment without fogging more than a few frames. Threading-up is also much simplified. On the other hand, the cassettes are not as definitely standardized in design as the spools are, and the cassette user is liable to find that, owing to some commercial affinity of which he was ignorant, the particular brand of film which he wishes to use is unobtainable with the cassette which fits his camera.

The advantages of being able to change unfinished spools are enjoyed by the owners of cameras which will wind the film in reverse, provided that they have the patience to count back accurately to the beginning of the unexposed section when changing.

A good deal of variety exists in the designs of viewfinders. The simplest kind is rather like a rifle-sight with a frame round the front component to show the camera's field of vision. Such a device is not rigidly accurate because the distance of the eye from the back of the sight may vary, but it has the advantage over telescopic sights, which are more precise, of giving a certain amount of visibility round the actual field of view, so that account can be taken of the movements of objects which are about to enter the field from outside.

In order to be reasonably accurate at close-up distances, it is essential that a viewfinder should be adjustable in such a way as to compensate for the fact that it takes in the scene as it appears from a point a little way off the actual lens. The adjustment is called compensation for parallax. However, for getting exact focus and exact field in near-up views of objects which remain stationary, no method is so satisfactory as inspection of the image thrown on a piece of film actually in the gate. It is therefore a great advantage in a camera if its construction is such as to allow of this. A gate which is readily accessible is also, of course, easier to keep clean.

The prices of sub-standard cinematograph cameras range from £7 to £150 according to the performance of which they are capable. It is possible, but by no means necessary, to spend a small fortune on accessories. Those who are richer in ingenuity than cash will find a very fascinating field of activity here. However, among extras which are beyond the scope of the handyman, but almost indispensable for serious work, one may include a tripod, a splicer, and some sort of exposure meter.

As for the handling of the apparatus, a cinema camera is in many ways easier to use than a still camera. The still cameraman must rely on the successful selection of a split second for his rendering of a facial expression or an action. The cinematographer gets the whole sequence of events, and if something superfluous is included, he can cut it out at leisure with a pair of scissors. He also

has at his command all the special effects ('tilting' and 'panning') which can be obtained by moving the camera vertically or horizontally while it runs.

A word of caution may, however, be added here. The young cinematographer is often run away with by this unaccustomed freedom, and led through sheer exhilaration into the error of keeping his camera continuously on the move while photographing. The result will be a very blurred and dizzy picture on the screen. The camera should only move for a definite purpose and must then move slowly and steadily.

Hard on the heels of buying a camera will come the need for a projector. These cost from £7 to £75 approximately. Up to a price of £50 or thereabouts, increasing price is accompanied by increasing light output, so that, while the cheapest machines might give a properly lit picture only 2 or 3 feet wide, the dearer ones will enable the picture width to be increased to 10 or 12 feet without undue loss of light. Alternatively, of course, they will give a small picture very brilliantly lit which will be useful for showing colour films to the best advantage, or exceptionally dense copies of black-and-white films, or for showing films of any kind when stray light is present. Beyond the £50 mark the increase in price represents more substantial construction rather than brighter illumination, and these machines are therefore of interest to the commercial or institutional user rather than the home enthusiast. These figures refer, of course, to silent projectors—sound projectors cost more than twice as much as silent projectors. The projection lamps used in home projectors range from 100 watts to 750 watts, while for projectors to be used in large halls, lamps of up to 1,200 watts and even arc-lamps are available.

Here again a word of warning may be useful to the purchaser who feels an unreasoning elation at the idea of acquiring a high-wattage projector lamp. A high-wattage lamp has a shorter life than a low-wattage one if it is run at its rated voltage, and costs more to replace each time it burns out. Moreover, light output does not

depend on wattage alone but also on the efficiency of the optical system and shuttering system. The amount of light cut off by the shutter depends upon how many blades the shutter has and on the width of each blade. On sub-standard machines a two-bladed shutter is only suitable for working with a picture of low light-intensity, and even then it may be necessary to run the projector somewhat faster than normal speed in order to avoid flicker. The width of the shutter blades depends on the speed at which the intermittent mechanism shifts the film. In this respect various types give widely different results. A cheap machine may employ as much as a quarter of each complete cycle in shifting the film, while a high-grade machine may perform the task in as little as one-ninth. Naturally the latter machine will have the narrower shutter-blades and will accordingly waste less of its projection light. In the sub-standard machines there is no one form of intermittent mechanism enjoying the exclusive favour of designers, as the Maltese cross does in the standard machine. Maltese Cross, Claw, and Beater (a piston-like device engaging the film between the gate and the bottom sprocket) all give results between which there is little to choose.

As projector designers keep in view the requirements of those who teach with the aid of the film, it is not unusual to find that projectors are furnished with the means of stopping or reversing the film. These refinements have, however, little interest for the average amateur, especially as the still picture procurable from a sub-standard film is a very hazy and spotty object, since the granular structure of the image becomes obtrusive as soon as a single frame stays still for inspection.

Efficient projection-lamps can only be designed to consume rather low voltages, and therefore some device has to be included for cutting down the voltage of the mains supply. A sliding resistance has the advantage of being equally suited to alternating and direct current, but a transformer, which is adapted for use with alter-

nating current only, draws a smaller flow of current from the mains and is, therefore, a great protection against the danger of blowing domestic fuses as well as a saver of expense in current consumption.

Finally—and this is a point which applies to cameras as well as to projectors—it is essential when purchasing to face the problems of service which are going to arise as soon as your instrument ceases to be brand new and develops one or other of those infirmities which all machinery is heir to. The natural source of such service is the shop at which you bought the machine. Is that shop, or one of its branches, so situated as to be accessible to you for the next few years? Has it got the outward and visible signs of commercial stability? These questions should be considered both in reference to the manufacturers and the actual sellers of the machine.

Unless he is fortunate enough to be projecting in a room with a blank white wall, the projectionist will require a screen. To obtain this may cost him a few pence or a great many pounds according to the size and construction of the screen which he requires. For the average living-room a screen from 2 to 3 feet wide will be large enough, and this may be made by pinning a piece of drawing-paper on to a bit of board, or distempering the board, or buying a piece of cheap white oil-cloth and using the back. Alternatively, a silver screen or beaded screen of this size may be bought without ruinous expense. The difference between these three types of screen surface—the white, the silver, and the beaded—lies in the way they reflect the projection beam. The white diffuses it all over the room, the silver throws it back in a narrow intense beam which falls away to darkness rapidly at its edges, and the beaded combines the best characteristics of white and silver, as it gives as brilliant a picture as the silver screen to those directly in front and no worse a picture than the white screen to those at the side. It is, however, the most expensive type, and no better than a silver screen in rooms where the audience can be kept from sitting at a wide angle to the screen. Fig. 38 shows the characteristics

of these three types of screen in diagrammatic form. Great ingenuity has been expended by screen manufacturers in designing portable screens which can be carried without damage and quickly put up for use. None is quicker to put up than those which rise up like an inverted roller-blind from a long wooden box. This type of screen, however, becomes a formidable addition to the projectionist's luggage if the screen is larger than 6 feet. In estimating the size of screen required, it may be assumed as a rough-and-ready rule that the screen width should never be more than 1/6th or less than 1/9th the distance from the screen to the back row of the audience.

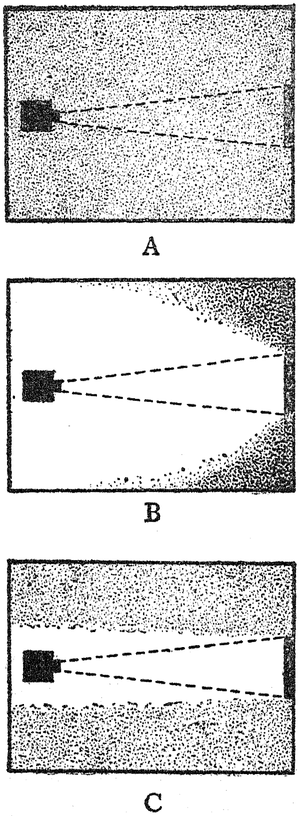


FIG. 38. Three principal types of screens. A. White. B. Silver. C. Beaded.

Another useful rule-of-thumb is that, with a 2-inch lens and 16-mm. film, the picture width will be about 1/5th of the throw. It would clearly be over-ambitious to attempt to conclude this chapter with a complete manual on sub-standard projection practice. The following tips may, however, save some of our readers a few tense moments.

1. Have a spare projection-lamp available.
2. Locate beforehand the fuses which belong to the electric point into which you are plugging the projector.
3. Have spare fuse-wire available.
4. Have an electric torch available.
5. Remember that a foot caught in the projector

cable may bring the projector down on to the floor—to loop the cable round the table leg may provide a measure of safety against this.

6. If you haven't the knack of making a broken film take up on a half-full spool, have an empty one handy in case of film breakage.
7. Turn the machine round by hand to see that threading is correct before starting the motor.
8. Check the resistance or transformer setting before switching on.
9. Stop immediately if you suspect that your loop has tightened up.
10. Keep your gate clean, otherwise you risk scratching other people's films.

CHAPTER XI

APPLICATIONS OF SUB-STANDARD FILM

THE FILM IN EDUCATION

It would probably be safe to assume that more than three-quarters of the film which goes into amateur cameras comes out adorned (if that is the word) with the faces of friends, relatives, or children, and views of holiday resorts. When thus used the cinema film is the legitimate successor of the family album. The film record has, of course, the advantage of being more complete and more vivid than a series of snapshots. On the other hand, snapshots can be shown without apparatus, preparation, or fuss, while cinema projection involves all these to some considerable extent. However, against the complexities and expenses of home projection may be set off the scope which it acquires from the professionally made films obtainable through various film libraries. The owner of a sub-standard projector can renew acquaintance with the heroes and heroines of the silent screen—Tom Mix the cowboy, Felix the cat, and Chaplin in his earlier phases, a delightful company well deserving the immortality they thus achieve.

There is a natural tendency among advanced workers in the field of amateur cinematography to plan something more ambitious than personal records which make no appeal beyond the family circle. There are a number of directions in which they may turn with every prospect of doing useful and interesting work. Appeal films for local charities may perform an immediate service, and descriptive films of our present customs, industries, and ways of life may all too rapidly acquire historical significance. Again, amateur film production may follow the main trend of professional production and seek to produce film plays. Such an activity is all the more easily organized as it is a logical development of that well-established institution, the amateur dramatic society. There are, however, two difficulties that beset the amateur production of dramatic films. In the first place,

the paraphernalia of indoor film production are necessarily somewhat elaborate and expensive, as the reader of Chapters II, III, and IV will have already realized; and in the second place, a certain lack of finished assurance in the acting, which may be rather disarming and even attractive on the gala evening of an amateur performance, becomes merely mawkish when fixed and as it were fossilized by the pitiless eye of the camera. Moreover, at present few amateurs have the financial and technical resources required for making talkie accompaniments to their productions whether on disk or film, and all audiences nowadays have grown so accustomed to the conventions of the sound-film that the conventions of the silent film strike them as stilted and unnatural.

Although the great majority of sub-standard cameras serve the purpose of a hobby for their owners, a large and constantly increasing number are in the hands of owners who use them as recording instruments in scientific research. Doctors, engineers, physicists, and biologists are among those who find that the sub-standard cinema camera is an instrument which will record for them with clearness, detail, and precision in cases where a written description would be hopelessly inadequate.

We may take as a typical instance the modern use of the cinema camera in connexion with aeroplane testing. A few years ago the testing of a new type of aeroplane consisted of one or more flights by a test pilot who got the 'feel' of the controls and reported on whether or not he thought the machine satisfactory. Such information is, however, of little use nowadays, and considerably more information is wanted on points in the performance of the machine which can only be measured by instruments. Thus, it is necessary to determine whether all structural parts are strong enough to bear the loads imposed by the particular design and maximum speed of the machine. This is done by putting the plane into a dive and flying it vertically downwards until it reaches the maximum attainable speed. At the instant it is pulled out of the dive as many as fifteen instruments are recording data which will give the required information.

Accordingly their dials are all collected on one panel which is recorded by a cine-camera. Such items as the deflexion of the wings during manœuvring may, in addition, be recorded directly by a separate camera.

Sport and science have now so much in common that this may be the appropriate point for mentioning race-timing cameras which are in use on several tracks in America. In one system of this kind the athlete (or horse as the case may be) interrupts a light-beam projected across the course on to a photo-electric cell and starts an electric clock associated with the 16-mm. camera. This camera has a double-lens train, one to photograph the winner and later arrivals crossing the line, and the other recording on the same frame the readings of the clock (Plate 21).

Apart from the use of sub-standard film as a very convenient material for recording instrument readings, it is finding increasing use in documentation. For example, cameras are in use which record on successive frames of 16-mm. film the cheques passing through banks, the contents of each issue of a newspaper, and so on. Not only do such cine-films provide a convenient and unquestionable record, but they enable large masses of material to be recorded in a very small space. In large firms and reference libraries this latter consideration is becoming of increasing importance, and microphotographic books have now materialized. A special small projector is made for use with these film books and can be used on the ordinary library table. The economy in space which results is such that the contents of a library of 8,000 300-page books could be stored within one cubic metre, and it was by this technique that a comprehensive account of modern civilization was recorded and enclosed within a metal cylinder which was ceremoniously buried on the site of the New York World's Fair in 1939. Whether the record made in this form will survive until A.D. 6939—the year fixed for its exhumation—is, of course, a point which, to say the least of it, verges very near the moot. However, to return to more conventional applications of sub-standard film, in industry it is used not only for purposes of research,

with a view to improved manufacture, but also for purposes of salesmanship. For example, a portable projector incorporating a daylight screen can be used by travelling salesmen to familiarize prospective clients with the care bestowed on the manufacture of the article for sale.

No account would be complete without some mention of the film's function as an educational tool. Yet the task of dealing satisfactorily in a few lines with so wide a subject is an unpromising one.

For nearly forty years the possibility of using films in education has been a favourite theme of discussion among theorists. During the first twenty of these forty years the fact that only inflammable film was available stood in the way of film projection in schools, nor was the introduction of safety film followed by rapid development, because the provision of a supply of suitable films presented a number of problems which had never been clearly thought out. The main difficulty lay (and still lies) in the making of the films. It was far from clear who ought to make educational films, how they ought to be made, and how they could be paid for. The idea that something was involved not unlike the composition of text-books proved to be quite misleading. The average teacher would find no particular difficulty in writing a text-book, because words are his stock-in-trade, and to write them is to the scholastic mind as easy as to speak them. But producing and stringing together a series of pictures so that they evoke exactly the effect desired requires skill in photography, experience in film editing, and a mind with a strong inclination to work in terms of pictures. Accordingly, every teacher is a potential writer of text-books, but a few only are potential producers of educational films.

Again, who is to pay for such films as may be made? All schools are users of books, but only those schools that own projectors are users of film. In the absence of films schools had no inducement to buy projectors and the deadlock appeared, therefore, to be complete. Certainly at any rate the educational field offered no temptation to the commercial producer.

It must have appeared to many observers of the situation, as it existed in, say, 1924, that nothing short of a generous state subsidy could break the vicious circle of no films if no projectors and no projectors if no films. A direct state subsidy would, however, have been contrary to the great British tradition of 'muddling through', and it was from a wholly unexpected quarter that help first came. In 1925, as an alternative to the imposition of preferential tariffs, the Empire Marketing Board was called into existence and endowed with considerable funds to be spent on fostering Empire trade. Film publicity was among the methods planned, and it was decided to see what circulation among schools could be obtained by offering to lend the films free to any school that could show them. The experiment met with success and was undoubtedly the inducement that led large numbers of schools to buy projectors. Moreover, the Marketing Board interpreted its mission in a very liberal manner and made a number of films of broad educational interest.

Meanwhile, the government had begun to move, though cautiously. In 1929 it appointed a commission to report on the use of cultural and educational films, and in 1933 the commission's recommendation, that an official body charged with the intellectual welfare of the film should be called into being, was fulfilled by the foundation of the British Film Institute. Once more funds were drawn from a curious source, namely, the money received by picture theatres from their Sunday audiences. In the same year one of the largest commercial film companies decided that the educational film was worth nursing as a speculation, and endowed a production unit for the making of carefully considered educational films. In 1935 the Board of Education formed a film committee among its staff to consider methods of fostering the use of films in schools, and in 1937 the committee organized the first official film course for teachers, which was held at Bristol. The most promising recent development has been the establishment of local libraries of films by the education authorities in London,

Glasgow, Birmingham, and Manchester. The number of projectors used in schools in Great Britain has nearly doubled in the last five years, and there are now about 1,750. Nevertheless, it may still be safely asserted that hardly one teacher in a hundred in this country makes any regular use of film projection, and our total of school projectors still compares very poorly with France's 10,000 and Germany's 35,000.

It is, however, an encouraging fact that the films which have recently been produced in this country both for specific teaching purposes and for the general purposes of background education have maintained a very high level of quality (Plate 5 and fig. 39). When we consider the very wide scope of educational films, we cannot doubt that they are destined to play a large part in the future both for actual instruction and for general cultural purposes of education. In the sphere of instruction the speeding up and slowing down of motion are the absolute prerogative of the cinema. Moreover, by means of animation, abstract phenomena can be visualized, and intangible phenomena such as the movement of sound waves in air can be presented in a way that no verbal description can rival, since comprehension of the concepts involved no longer depends on the student's vocabulary but on his innate mental ability. Then again, the number of related ideas and concepts that can be accurately presented within a few minutes enables such concepts to become closely integrated, and the relationships of one to the other to become self-evident. In the sphere of background education the film may be specially useful in counteracting the danger of over-specialization. For example, a student of law who cannot afford the time, even if laboratory facilities are available, for a practical course in general science, can gather from a well-constructed film the broad outlines of scientific method. Such films, besides giving close-up records of experiments which always go right, can compare these graphically with natural phenomena and industrial processes. It may be noted that in the University of Chicago regular use is made of films

designed to be part of general courses in the humanities, and the social, biological, and physical sciences.

The value of 'background' educational films may be aesthetic as well as intellectual. One may mention especially in this connexion such films as *Night Mail* with its delightful sequence of engine-rhythm verse, and *Song of Ceylon* (Plate 12), which perhaps goes farther than any other film yet made towards fitting photographs of hard fact into a lyrical composition.

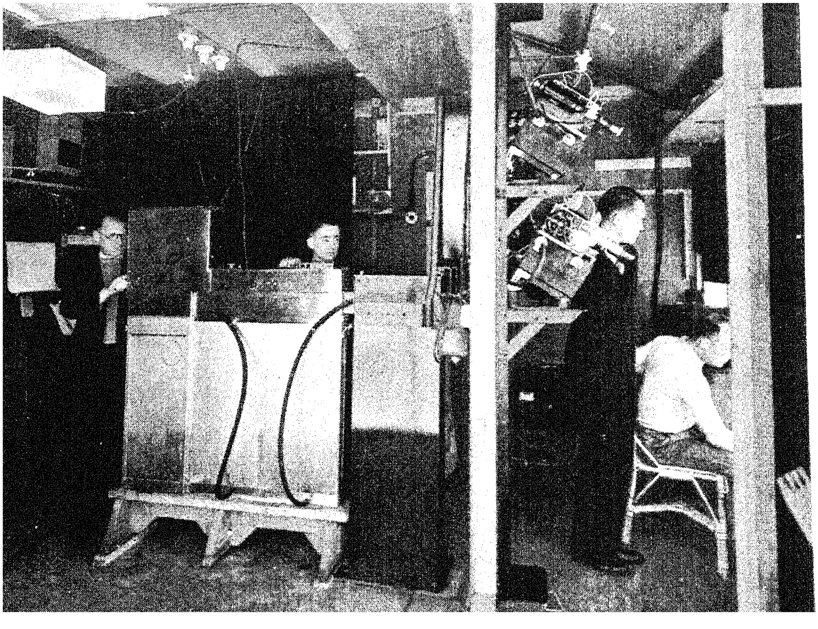
Before we take leave of cinematography in schools it may be interesting to note that the camera as well as the projector may play a part here. Interesting experiments have been tried in making film records of school activities and even in the production of teaching films, some being made by teachers alone and others by teachers and students in co-operation. As a pleasing example of highly organized co-operation it would be hard to beat the colour film recently made at Ealing Technical Institute. The subject was 'Noah's Ark', and the treatment was somewhat in the manner of a medieval mystery play. The costumes and scenery were designed by the Art Department and carried out by the Dressmaking and Carpentering Departments respectively. The actors and actresses were provided by the Institute's Dramatic Club, and such parts of the Flood as could not conveniently be enacted on a large scale were faked on a small scale with the assistance of the Model-making Department. The actual taking of the film was, of course, the business of the Photographic Department. The delightful film which resulted may be taken as a demonstration both of the large number of different crafts required for the successful production of a dramatic film and of the many-sided activities to be found within the walls of a modern Technical Institute.

The use of the film in churches and local halls for purposes of religious instruction has recently begun to make substantial progress, due in part no doubt to the improved performance obtainable from sub-standard projection.

Hitherto the terms 'sub-standard' and 'amateur' have been almost synonymous, but recently the results

From 'The Great Train Robbery', produced for Edwin S. Porter for Edison in 1903
—the first American story film of importance

By courtesy of the National Film Library



Race-timing camera in operation. The tank behind the camera is for the rapid development and printing of the picture

By courtesy of Harry J. Day

From 'Dante's Inferno' (Italy, 1912): Dante and Virgil behold the spirits of the luxurious tormented by a storm of wind

From 'Cabiria' (Italy, 1913), made from a script by D'Annunzio, an example of the grandiose spectacle film popular at that date

By courtesy of the National Film Library

obtainable from 16-mm. film have reached so high a level that some encroachment by sub-standard film on domains which have hitherto been reserved for standard film is to be anticipated. For instance, there are already theatres in this country where local newsreels on 16-mm. film form part of the regular programmes; or again, one may mention the 'Bantu Film Experiment' recently carried out with the aid of a Carnegie grant. This experiment consisted in the making of films in Africa with African actors, to promulgate ideas of thrift, good agriculture, hygiene, and so forth. Sixteen-mm. film was used throughout in this experiment with a sound accompaniment recorded on disk.

The application of a satisfactory sound-track to 16-mm. film has been a matter of considerable difficulty, chiefly because the sub-standard film travels at only 2/5ths of the speed of 35-mm. film, so that the track had to be compressed both in length and width. These difficulties have now been overcome, the track being recorded at slightly less than standard width down one side of the film (Fig. 37). The quality of sound now obtainable is at least as good as from a first-class radio set, and 16-mm. sound-film is advancing into what was 35-mm. territory, while the quality of the image on the screen is already such that an audience of 1,000 may not suspect that they are viewing sub-standard projection.

Although, therefore, the immediate future before 16-mm. film would appear to be industry, education, and non-theatrical fields, all of which are expanding rapidly, it is not beyond the bounds of possibility that it will make serious inroads into the theatrical field. In Russia, for example, thousands of villages have a population too small to necessitate the standard equipment, while in the U.S.A., the centre of the motion picture industry, 3,000 small theatres are closed because operating costs of 35-mm. sound are too high for the audiences they cater for. Of 15,000 theatres in the U.S.A. about 70 per cent. have capacities for 600 persons or less. All such theatres could utilize 16-mm. sound without detectable loss of quality and,

of course, very considerable economies in equipment, running costs, and fire risks. Indeed, the only important factor hindering this development is the unwillingness of the large film-producers to permit the release of 16-mm. versions of their current films. In Britain Gaumont British have made a step in this direction, however, and now release current productions on both 35-mm. and 16-mm. film, and several English theatres are equipped only with 16-mm. apparatus.

On the whole, however, we may assume that sub-standard will continue to cover separate fields from standard for some years to come.

Among the developments which we may expect to see in a more or less remote future are animated posters projected through daylight screens from automatic projectors which will either run film in an endless band or else have a device for automatically reversing the run of the film. Machines for both types have been hanging about in the limbo of nearly practical apparatus for the last twenty years, exciting exaggerated hopes in the hearts of their inventors and exhausting the patience of their users by frequent breakdowns. It seems probable that these machines will be designed to use sub-standard film. For museums such machines would, of course, serve a variety of useful purposes. Living animals in their natural haunts could be shown in natural history museums, and full-scale apparatus at work in factories or laboratories could be shown in science museums. In America the museums are already making themselves responsible for the production and distribution of scientific films. It is likely that the use of sub-standard films for scientific purposes will gradually increase all over the world until all learned societies will think it as natural to possess their own film library as their own book library. Another line of development which might result from the invention of reliable automatic projection would be the moving-picture gallery in which short films of artistic merit could be shown running simultaneously side by side, with or without the gilt frames which it is usual to bestow on works of art.

Our present experiments in introducing the sub-standard film into the classroom for educational and training purposes are only a beginning which in years to come will seem as primitive a method of using a wonderful power as Hero's steam engine. Already we have a hint of one future development in those films and photographs which, by recording the light from tiny lamps fastened to a worker's hand, enable us to analyse and frequently simplify the movements that he makes when performing repetition operations. H. D. Hubbard in a most interesting paper on this subject (*Journal of the Society of Motion Picture Engineers*, May 1921) has pointed out that experts and champions do not know the secret of their own skill, and are therefore helpless to impart it; the motion picture knows no such limitation.

It is possible to imagine a slow-motion record consisting of the best elements of the skill of a hundred different masters acting as a consummate model excelling the performance of any human individual, which could be used to impart that skill to the whole world, the film repeating the lessons as often as needed and at the optimum learning speed.

Hubbard gives, as examples of next steps in the application of the film to teaching, the possible development of modified projectors for teaching dancing and the piano.

'Project moving footprints from below on a ground glass floor showing the steps of a given dance. The pupil follows the steps with his feet, regulating the movement from slow to normal as skill develops. The same film which projects the footprints may also give a life-size picture of a skilled dancer executing the same steps in exact time with the moving footprints or slightly in advance of them, the picture turning so as to follow the turns of the dancer and remain in view. From time to time helpful comments could be included as part of the film projection giving the perfect evolution by the shadow footsteps. The complete system would thus be a unified instruction by diagram; picture, words, and music all in perfect synchronism and all selected as the most skilled rendering available. Apply the motion picture to piano self-instruction. Project above and along the keyboard from one side of the piano a motion picture of the master pianist's hand, showing his fingers executing, say, the chromatic scale. A plane or concave glass plate set at 45 degrees forms a kind of camera lucida which reflects the picture to the pupil's eyes. He can thus with his own fingers follow the master's hand and every

setting and stroke of each finger and every turning of the thumb. The silent phantom of the master's hand, the immortalised skill, would be better than the presence of the master himself and far less disconcerting, for with joined ends the film could patiently repeat the motion as often as needed, and at any speed, steadily faster as skill developed. Likewise every difficult bit of technique could be taught by masters whose movements would be recorded as we now record their music. The engineer must design simple and suitable projectors for the purpose, as easy to operate as a metronome, and a set of instructional films must be prepared by masters of their art.'

Such suggestions are not as fantastic as may appear to be the case at first sight, though admittedly our earliest attempts at applying cinematography to such ends will probably be clumsily inefficient. But it does not require a very vivid imagination to realize that if cinematography continues to advance during the next fifty years at the pace it has set for itself it may easily become the supreme habit educator of our race, summing up in its records the experience of the world, so that no new knowledge is lost, and our grandchildren may all begin at the highest point of skill their fathers had attained.

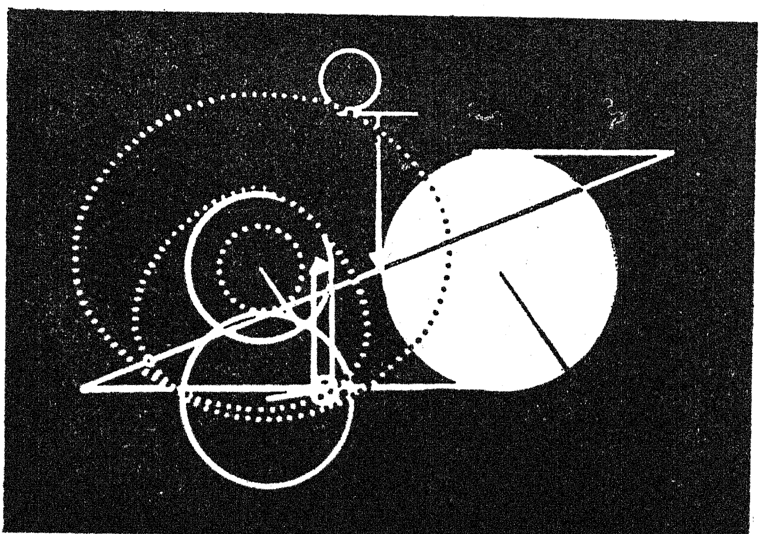


FIG. 39. A still from the film 'The equation $\ddot{x}+x = A \sin Nt$': a moving diagram simplifying the teaching of mathematics.
(By courtesy of B. G. D. Salt.)

CHAPTER XII

THE FILM YESTERDAY AND TO-DAY

IN previous chapters we have dealt with the development of film apparatus treated as mere machinery. But we have to bear in mind that the object of this machinery is to screen a picture, and that the object of nine-tenths of the pictures screened is to make some sort of dramatic appeal. Accordingly, it is as an artistic medium that we must view the film if we are not to disregard one of its most significant aspects.

When one compares any branch of scientific development with any branch of artistic development one is struck by the success with which mankind maintains a steady upward climb in matters of science but is doomed to a series of ups and downs in matters of art. Every day and in every way cinematography viewed as an engineering job has got better and better. Viewed as a form of art we see it moving, like any other form of art, to and fro from worse to better and from better to worse. In spite of the blatant promises of film publicists, it would be as absurd to expect each year's films to be better than those of the year before as to expect each year's Royal Academy Exhibition to excel the previous one. To emphasize this is not to belittle the work of the technicians. In the films more than in any other form of art, technical problems tend to overlap creative ones. But if film criticism is to have a firm basis it is necessary to preserve this distinction between technical and artistic excellence as far as possible. Moreover, this distinction will help to foster an understanding attitude towards revivals of film classics which sometimes tend to provoke quite needless outbursts of giggling on the assumption that, their technique being different from that of the modern 'talkie', they are necessarily merely quaint.

The artistic development of the film is especially interesting because we can go back to the beginning of the story and watch film as an Art developing as an exceedingly, perhaps excessively, lusty off-shoot from film as a Science.

We know nothing of the origins of music and nearly nothing of the origins of painting and sculpture, but we do know that the film began its existence as a record of facts, and only gradually acquired a tendency to wander off into that land of make-believe which we have now come to regard as its natural habitat.

Moreover, for nine-tenths of us, the film is not merely an Art but The Art. Every week in this country a few hundreds of us go to the picture galleries and a few thousands to concerts but over twenty millions to 'The Pictures'. Nor can the cultural problems which are raised by the sudden appearance on the scene of this new popular art be disposed of by the trade's pet private apology that the film is 'merely entertainment'. Art does not cease to be art when it begins to please the populace. If it assumes that the populace has extremely bad taste and moulds its products on that assumption then it becomes extremely bad art, but still classifiable as 'art' if the word is to have any logical meaning at all.

It is with justice, therefore, that recognition is at last being given to the need for studying the history of the film as a branch of art history. Until two or three years ago there were no public schemes for the preservation of films such as have long existed in the case of pictures and books. Only chance and the enterprise of a few private collectors has saved such early films as still exist from a variety of evil fates which await discarded films —scrapping for the recovery of raw materials and especially silver, breaking up into short lengths for toy projectors, or exporting to the so-called 'backward' countries which still possess facilities for running silent film. Now, however, Great Britain has a National Film Library (under the aegis of the British Film Institute), and a Federation of National Film Archives has been formed linking the British Library with similar institutions in America, France, and Germany. The British National Film Library already contains over two million feet of film, and a substantial start has thus been made towards providing film historians with definite data on which to work.

The outline of the film's development as an art which we are including here is necessarily sketched in a very foreshortened style since the subject is more suited for the filling of a volume than a single chapter.

The first programme of films shown publicly in this country—that displayed by Lumiere at the Polytechnic in May 1896—was already compounded of two ingredients, the factual and the fictional. The factual was represented by such subjects as a train entering a station, and the fictional by M. Trewey, Lumiere's assistant, doing impersonations with the aid of a large and flexible hat.

Mechanical considerations at first limited the reels shown to a length of about 50 feet, or something under one minute's screen time. Soon, however, this length was increased to 1,000 feet. A reel of twenty minutes duration gives scope for a considerable display of fact or play of fancy, and within a few years exploration had begun along all the main avenues of subsequent development. In Great Britain, newsreel work occupied the foreground, special interest being aroused by faked films of the Boer War. R. W. Paul, well known also as a designer of early projectors, made many ingenious trick films (Plate 16), Cecil Hepworth blended comedy, trick-work, and romance with a very nice judgement (Plate 16), while from a provincial company came in 1903 *The Life of Charles Peace* (Plate 20), forerunner of a long line of crime films.

In France the trick film made rapid headway under the guidance of the ex-conjuror Melies. The rather florid vein of fantasy which runs through his work makes no direct appeal to a modern audience, but he was a prolific and ingenious worker who deserves to be remembered among the pioneers of production. A number of his working drawings have been preserved (Plate 20). France also claims an early exponent of the cartoon film in Emil Kohl (Plate 15). In America, film production is generally reckoned to date from Edison's *Great Train Robbery* of 1902 (Plate 21). The idea that thriller films might meet a popular need provèd, from the financial point of view, a happy inspiration. Practically everybody could afford to go

tô the pictures. Working-class audiences filled and overflowed the adapted shops in which early displays were given, meeting-halls were converted, and picture-show 'Alcazars' and 'Alhambras' sprang from the ground as at the touch of Oriental magic. Film making grew from a hobby into a trade and from a trade into an industry. With somewhat short-sighted haste all things filmable—plays, novels, and historical episodes—were transformed into film in as literal a manner as the limitations of the medium allowed. The creative characteristics of the medium, the effects obtainable by planned lighting, camera position, and editing were only dimly guessed at. In the turmoil of expansion the only quality maintained was photographic clearness, and the products of this period suffer from a crudity of conception which makes them wear very ill as works of art. Nevertheless, it must be borne in mind that it was during this period of hectic activity that a nucleus of technicians acquired a quantity of practical experience. Moreover, the film industry, through becoming rich, began to become respectable, and actors and actresses of repute ceased to refuse film contracts.

Perhaps the most remarkable products of this era are the ambitious spectacle films produced in Italy such as *Quo Vadis*, *Dante*, and *Cabiria* (Plate 22). It was, however, in America that the swing of the pendulum towards the production of less crude film dramas began. Towards the end of the year 1913 D. W. Griffith, at that time producer for the Mutual Film Company, was already discussing plans for his great historical epic of the American Civil War, *The Birth of a Nation*. The subject was, however, too controversial, the colour-problem was treated in a strongly partisan manner, and the technical methods he proposed to use were too novel for the conservative taste of his employers. Griffith, however, ultimately obtained financial support, started his own company, and made the film in accordance with his own ideas, which were far in advance of those prevailing at the time. His dramatic effects depended upon the rhythm of his composition, whether he was handling

crowds or individuals, and the rightness of his camera's viewpoint, rather than on the gestures and facial expressions of individuals. He thus broke completely with the traditions of the theatre. The resounding success of the film was, of course, partly due to the political excitement which its showing engendered, but beyond and above that, the film compelled general recognition that a milestone had been reached on the road of the film towards serious accomplishment. It demonstrated the possibilities of one type of film, the type that owes the maximum to the creative ideas of a producer and a minimum to the abilities of actors.

This, however, is not the only possible type of successful film. The functions of producer and principal actor may be combined. In fact, simultaneously with the first rumours of Griffith's forthcoming epic an event took place which was destined to illustrate vividly how successfully this may be done. Towards the end of 1913 an English music-hall comedian, Charles Chaplin, was persuaded to leave the stage and join Mack Sennet's 'Keystone' film company (Plate 23).

It is necessary to note that the seeds from which most of what is best in the American film industry sprang were planted well before the outbreak of the European War,[1] because credit is sometimes grudged to its achievements on the ground that their origin was the cessation of rival activity in European film studios. This cessation undoubtedly increased the quantity of American productions for many years to come, but does not by itself account for the high level of excellence which, from now onward, they often reached.

In the fourteen years which elapsed between 1914 and the coming of the sound-film the technique of the silent film was perfected. Long captions and exaggerated gesticulations were a thing of the past. The art of telling a story in terms of appeal to the eye had been mastered.

In Europe the most notable contributions towards this end were made by France, Germany, Russia, and

[1] We refer to the first war! This book was written in 1938–9.

Sweden. France at first directed her energies to the production of historical epics which reflected the heightening of national consciousness by the Great War. As the effects of the War died down a fortunate turn of fashion allowed full play to the mordant wit of René Clair's comedies. Germany too showed at first a preference for epic themes, but chose myth rather than history, and lavished the great technical resources of the Ufa studio on film versions of the Niebelungen Saga (Plate 24). Later, when the grand manner began to pall, a period of impressionist experimentation set in, of which the best-known product is the somewhat morbid *Cabinet of Dr. Caligari* (Plate 24).

In Russia the film served the purpose of initiating a largely illiterate populace into the doctrines of Communist ideology, just as the mystery plays of the Middle Ages were used to popularize the tenets of the Church. Fired with political fervour and a frenzied zeal for every sort of experimentation, the Russian directors made important contributions to the technique of the film as an instrument of emotional appeal. The Swedish studios displayed that strong originality in dramatic technique which was to be expected from the countrymen of Strindberg. It was, of course, in Swedish studios that Greta Garbo began her career.

Great Britain achieved no special success as regards dramatic films. If we seek creative imagination in British films of this period we shall find it rather in the 'Secrets of Nature' series of popular science films which introduced the public to the fascinating mystery of plants which grew beneath the eyes like Jack's beanstalk, and in well-arranged records of fact such as John Grierson's propaganda film for the British fishing industry, *Drifters*.

In 1928 an event occurred which turned the whole history of film production off at a tangent. The sound-film, which had been a practical possibility for some time, was introduced to the public by Warner Bros.

The inhabitants of all civilized states seem to be peculiarly sensitive to any suggestion that their amusements are not the last word in scientific complexity, and

the silent film became obsolete as entertainment with surprising speed. One result of this turn of affairs was to restore to America the predominating position acquired during the war, for American interests had secured master-patents which gave them, for the time being, almost exclusive control of the manufacture and sale of sound-film apparatus. Another result was that from the creative point of view the films slipped back into a second childhood. So long as 'the talkies' were a nine days' wonder the exhibitors had only to announce a '100 per cent., all-talking, all-singing film' and reap the profits without troubling overmuch whether the talking was witty or the singing melodious. Moreover, the early sound-recordists could only work indoors and could not cope with actors who moved about freely. Accordingly, the old ideal of films as mechanical transcripts of theatrical technique was temporarily revived. This setback proved, however, to be only temporary. Since 1914 the film had attracted to itself a growing number of technicians and artists possessing a real understanding of the problems involved, and a growing public ready to appreciate a good film when it saw one. Before long the recording of sound had gained greater latitude, and the use of the sound-track for a blend of speech, natural sound, or music had passed into the stock-in-trade of the film's expressive resources. The sound-film as we know it to-day had arrived.

Further unsettlements were, it is true, soon to be introduced by the increased use of colour film, but predictions that colour films would come with a rush, as sound-films had done, proved premature. Up to the present it might well be maintained that the most successful use of colour has been seen in Disney's cartoons. It might even be maintained that their ingenious accompaniments represent the most successful use of sound But it would clearly be an idle task to attempt to invent canons of good taste for the evaluation of the many million miles of film which have passed through projectors in the last forty years. If we feel inclined to complain because good films are so few and far between,

we should bear in mind that there are special difficulties which obstruct the production of good films. In the first place, films are expensive to produce. This fact breeds in the minds of those who guide the destinies of the film an inclination to 'play for safety', which usually manifests itself by clinging to the theory that nothing succeeds like imitation of past successes. This theory hampers that freedom of experiment which is necessary for the healthy development of any art.

Again, the cinema has all the drawbacks of a compound art. So many individuals and interests have a share in shaping the final product that only a miracle or a particularly dominating individual can prevent it from becoming a patchwork of ill-assorted contributions. Moreover, even those average films that fall very short of being successful works of art contain far more successful artifice than is generally realized. The audience get the impression of being actually present at a series of real events which they can follow by merely keeping their eyes open. They do not realize the amount of experience, intuition, discussion, and thought that have gone to directing the players, placing the camera, controlling the light effects, judging the right length for each consecutive bit of action, and composing suitable blends of sound for each inch of the film. The illusion of reality which is obtained by the average sound-film to-day is so complete that the addition of colour or stereoscopy appears to some to be an unnecessary technical complication. While the authors do not agree that this would be the case, they admit that if a film fails to grip and we find ourselves indifferent as to whether the heroine succumbs to the villain's wiles or resists them, the cause is not that the villain and the heroine have only one colour and two dimensions. The ingredients on which illusion depends are more subtle than that. It is these subtleties which the discriminating film-goer gradually learns to appreciate. Some knowledge of the film's past is the best possible basis for an understanding of the fundamental problems of the film's present and future.

Those responsible for choosing programmes for schools and institutions should bear this in mind, and aim at selecting items from the Film Library catalogues which can be presented as classics, with some words of explanation as to their historical interest in the film's development and their intrinsic artistic merits. Recently several composite films made from extracts out of early films and designed to illustrate particular phases of the film's development have been issued by the Loan Section of the National Film Library.

In American schools and universities Film Appreciation is included as a subject in the regular curriculum. There is no sign as yet that any educational institution in this country is prepared to follow this lead. But there are many ways in which teachers can, without formality, coax their students towards an educated taste in films. They can adopt a sympathetic attitude towards film-going, bring it to the notice of their classes when a good film comes to the local cinema, ask leading questions which direct attention to the points worth looking for in a film, and set essays calculated to encourage critical appreciation of films. Schools with projectors can, as was pointed out in the last chapter, examine films from the historical aspect. They can also see and discuss documentary films.

Finally, of course, there is always the possibility, in any town where a sufficient body of enthusiasts exists, of banding together into a Film Society and hiring a cinema in which to give special shows of films chosen by the members of the Society. Ever since the foundation of the London Film Society in 1925, the greater part of the pioneer work of film appreciation in this country has been performed by organizations of this type, whose efforts have paved the way for the establishment of the many specialist and repertory theatres which now flourish in considerable numbers both in London and the larger provincial towns.

To some extent, of course, the problem of bad films is part of the very far-reaching and important problem of the commercially produced mental fodder which

modern conditions tend to provide for our consumption. The crudely sensational film, novel, and newspaper all spring from the same parentage—the union of imaginative creation with modern commercial methods. It seems strange that there is so little uniformity about the antidotes recommended in each case. The best remedy for the habit of reading bad books is universally agreed to be an introduction to better books. But all too frequently it is assumed that the only line to take with children who batten on bad films is to warn them solemnly against ever seeing any films at all. There is a difference between discriminating and promiscuous film-going which cannot be too strongly emphasized. Besides, even the worst film would afford material for critical discussion. Striving to define what is wrong with a bad film is an excellent intellectual exercise.

CHAPTER XIII

THE FILM INDUSTRY. THE FILM AS A SOCIAL FORCE

SPEAKING very broadly, the commercial film industry falls naturally into three divisions—the Exhibitors, that is to say the owners of the picture theatres, the Renters, that is to say the agents from whom the exhibitors hire their films, and the Producers, who make the films.

This classification is only approximate, both because there are, as we shall see, other lines of subdivision which cut across these primary ones, and because there are a large number of subsidiary industries which it fails to include, such as the manufacture of raw film stock, the processing of the film, and the making of cameras, projectors, and other bits of cinema machinery.

Some account of the exhibiting side of the industry has already been given in Chapter VII.

The present number of picture theatres operating in Great Britain is slightly over 4,800. Well over a third of these belong to groups or 'circuits' as they are called. In some cases the groups are associations of picture theatres only, and in others a group of picture theatres may be controlled by a production company.

The renters in this country are sharply differentiated according to whether the interests which they represent are British or American.

The American renters are naturally concerned mainly with the sale of pictures made in America.

The British renters, on the other hand, take an active interest not only in the marketing but often also in the production of British films, and the renter's contract to handle a picture when completed is often the guarantee that enables the balance of the necessary finance to be found. The work of film production has been touched on in Chapter IV. Here again there are subdivisions of interest which reveal themselves when any attempt is made to frame laws beneficial to producers in general.

Those who produce feature films, i.e. films about

7,000 feet in length costing from £6 to £12 a foot, have problems to face which differ greatly from the problems of short-film producers, whose films are from 1,000 to 2,000 feet long and can generally be made for from £1 to £2 a foot.

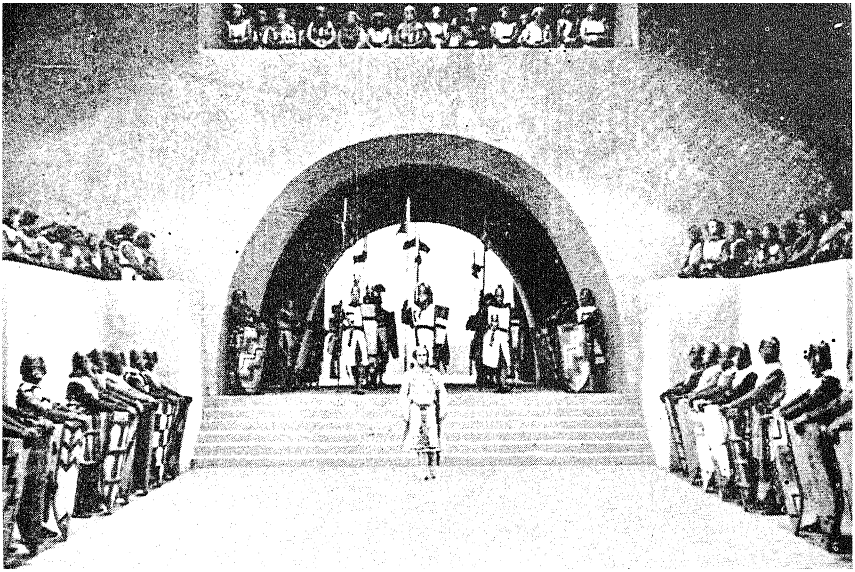
Since the war of 1914–18 British production has had a chequered career. The assumption that this was in large part due to American competition was natural, and in 1927 the Quota Act was passed to ensure that a definite proportion of British film programmes should be British-made films. Unfortunately, during the ten years covered by the working of the Act, it became clear that the English industry's troubles did not all originate abroad. Although some fine films were made during this period, so much borrowed money was lost that financiers began to fight shy of the industry as a field for investment, and in 1938 the studios were almost standing idle. The guarantee of ten further years of protection by the recent renewal of the Act has set the wheels turning again, but at the time of writing more than half the skilled film-technicians of the country are out of work. Some of the reasons for this state of affairs are not difficult to find. For example, a considerable prejudice was produced against British films by 'Quota Quickies', a worthless type of minimum-cost film produced in this country by American interests in order to satisfy the letter of the 1927 law. Proceeding to the opposite extreme, English interests imported American-trained technicians, stars, and business methods in the belief that the formulae which worked so successfully in Hollywood would succeed in England. The fact that Hollywood had set a pace that we could not profitably hope to follow ought to have stimulated the British industry into pursuing a different policy in film production to that of aping Hollywood standards. Assured of a world market, it is practical politics for Americans to shoot 100,000 feet of negative to obtain a 7,000-foot film and to pay actors and actresses salaries which make those of Cabinet ministers sound like tips; but these are not the only conceivable formulae for making a profitable film. The 'Secrets of Nature', and films made by the

Chaplin, Marie Dressler, and Mabel Normand in 'Tillie's Punctured Romance' (Mack Sennett, 1914)

The film was derived from a stage play in which Marie Dressler had scored a success. Note the stage curtain persisting even in the film. This was the first film comedy reaching modern feature-film length ever made *By courtesy of the National Film Library*

Chaplin in 'Modern Times' (United Artists, 1935)

The film is a satire on modern industrial conditions. There are no spoken words on the sound-track except those produced by a sales-talk disk and the gibberish which Chaplin improvises when he has forgotten the words of his cabaret-song *By courtesy of United Artists Corporation*



From 'Siegfried' (Germany, 1923): Siegfried comes to meet King Gunther in his palace

From 'The Cabinet of Dr. Caligari' (Germany, 1919)

With its distorted scenery representing the world as seen through the eyes of a madman, this film was a pioneer experiment in the horrific *By courtesy of the National Film Library*

G.P.O. film unit, for example, have demonstrated that audiences can appreciate films made at a fraction of 'super productions' costs by the exercise of business methods that are a *sine qua non* in other industries.[1] These particular films are frankly 'educational', and it is not seriously suggested that 'entertainment' films could be made in which there was a similar ratio between production costs and effectiveness. On the other hand, a case can be made out to show that the raising of the intellectual level of the average feature film will only be practical politics when there is a considerable lowering of production costs. Although it has yet to be demonstrated that it is essential to spend fifty to one hundred thousand pounds on making a feature film before it can hope for a world market, broadly speaking, while costs of this order are involved, it is necessary to make the treatment an appeal to the emotions rather than to the intelligence.

The reason for this is to be found in the enormous size of the audience which must pay to see such a film if it is to make a profit. The film to-day is an entertainment for the masses, and whereas the theatre has a specialized and discriminating public, film audiences are for the most part people of slender means who find in the cinema a means of escape into a world where, since they usually, if unconsciously, identify themselves with one of the 'stars', they can revel in luxury, excitement, and emotions foreign to the humdrum routine of their daily lives. If the people who collectively are financing the industry with their sixpences are for the most part simple-minded, unsophisticated, of no great education, and of little discrimination, that is not the fault of the film producer; and, when he is gambling fifty to one hundred thousand pounds of his backers' money, who can blame him for chosing his story and treatment with a mental picture of the queue outside a small town or suburban cinema in his mind?

The intellectual standards of the film industry are,

[1] It is reliably reported that in the making of a recent English feature film 650,000 feet of negative film were exposed!

however, a matter of more than industrial importance. Whether we like the idea or not, every film shown in the picture theatres is an educational film in the sense that it puts ideas into the heads of the audience. When we remember that many children, rich as well as poor, visit the cinema regularly twice a week, we cannot but realize that to-day's films must be leaving their mark on the minds of to-morrow's citizens. Our first impulse on discovering that the young are in danger of corruption from the pictures, the picture papers, and the modern novel is, of course, to invoke the good offices of the censor.

Already the censorship of the films is organized on a more elaborate basis than that of the press, since the press has only to avoid such extreme breaches of polite behaviour as would contravene the law of the land, while the films have voluntarily submitted the regulation of their own morality to a trade-appointed censor who not only indicates his views as to what is completely unfit for public exhibition but also issues warning certificates as to such intermediate grades of unfitness as 'A' (for adults only) and 'H' (horrific).

On reflection, however, one cannot but realize that a film may, through sheer silliness and mediocrity, exercise a deplorable influence on the young without coming within a mile of the censor's ban. In fact, it might be maintained that the censorship as at present wielded encourages the films to be silly and mediocre by inclining to the view that 'nothing controversial' shall appear on the screen. The corollary of this view is that the screen can have no legitimate aim other than the crudest kind of entertainment, and that it is essential for the cinema theatre to be kept as a place fit for fundamentally frivolous people to sit in. The argument that the workers of the world need somewhere to relax is bound to make a wide appeal, because the picture of ourselves as workers who have earned a rest is one which we are quick to recognize and slow to disclaim. But there seems some doubt as to whether Destiny proposes to go on indefinitely endorsing this agreeable

view of our situation. Our freedom to enjoy our leisure in any way that our fancy dictates rests upon the continuance of a civilization in which alarming cracks have already appeared. Human institutions are clearly failing to adapt themselves to the changes of circumstance brought about, often unintentionally, by human ingenuity. The triumphs of the scientist have become the despair of the sociologist. In times of stability the common man may sit back in his arm-chair (or cinema seat) and leave politics to the politician. But in times of crisis it is clearly the business of every man capable of thinking to give some thought to the factors which face us with unemployment and exasperated racial egotism and threaten us with world-wide war. Our civic duty goes a good deal beyond spending a few evenings at lectures on aerial warfare as it will affect those civilians who happen to get underneath a bomb. Only the most extraordinary and fatal degree of mental lethargy can lead us to accept as self-evident the proposition that mutual destruction is a natural and inevitable human activity. We ought to subject the social and political conditions which breed hatred to as close a scrutiny as is given to the unhygienic conditions which breed disease. Moreover, if our casting of votes as citizens of a democratic country is not to be a farce, but is to make some intelligent contribution to the world affairs of the future, we need to keep ourselves well informed as to world affairs of the past and present.

Now here at once we are faced with the problem of transcending our own natural limitations, our limited interests, time, energy, and memories. It is to adult education chiefly that we must look for the solution of this problem, because as the sum total of human knowledge has been expanded in the last 500 years out of all proportion to the individual's scope, the school curriculum is already packed to bursting-point. One must, however, face the fact that the average adult is simply not going to sit down and study historical text-books and political tracts in his spare time, and that if he did so out of a dour sense of duty he would probably get

but little benefit. Press, radio, and film are the three main channels through which ideas can be conveyed to the mind of the average citizen in a modern state, and it is the film which delivers ideas in their most vivid form. In the newspapers the victories of violence, especially in a remote country, tend to strike one as items in a numerical statement which leave the emotions untouched however vast the total. A few hundred feet of film taken on the spot will almost inevitably give the same events in a truer emotional perspective. In order to learn the value of law and order it is not enough to have read about outrage and disorder; one needs to see it, even if only on the screen. Although owing to speeding up of communications the circle of what affects us practically has spread almost to the limits of the inhabited globe, the circle of what affects us emotionally still tends to enclose our immediate familiars only. It may, therefore, well be maintained that frank unpalliated newsreels are educational in the truest sense of the word, and that our impulse to suppress them arises from a very misleading sort of squeamishness. Newsreels should not be encouraged to paint a picture of our globe which smooths out the wrinkles. While they should avoid morbid sensationalism they should also avoid glossing over the seamier sides of the picture presented by twentieth-century civilization. Moreover, the mere stringing together of moving snapshots, valuable as it generally is, by no means exhausts the possibilities of the film as a mirror of the modern world.

'Documentary' is a word which has been so enthusiastically incorporated into the jargon of film patter that one rather hesitates to use it, but it is at any rate a convenient inclusive label for the sort of pictorial essay which has flourished in this country for some ten years now, thanks largely to the efforts of John Grierson and his school of 'realist' producers. In these films a single theme is worked up in such a way that its latent dramatic possibilities are utilized without distorting the essential truth of the presentation. Professional actors are not usually employed, and the commentary is often spoken

by the man whose job is being portrayed. Grierson's *Drifters* produced in 1928 for the Empire Marketing Board is usually regarded as the prototype of these films in this country. The Empire Marketing Board Film Unit was taken over in 1931 by the G.P.O. and has since issued a number of fine studies based on the theme of communications such as *North Sea* and *We Live in Two Worlds*. *North Sea* exemplifies the assistance given to ships in distress by means of ship-to-shore wireless signals, and *We live in Two Worlds* shows the breaking down of natural barriers by modern methods of communication as a step towards international co-operation. Another government department which has made use of films for the public relations side of its work has been the Ministry of Labour with *Workers and Jobs* (1935), *On the Way to Work* (1936), and *Work waits for You* (1936). These, however, are isolated instances, and the filling of this very obvious gap in our cultural resources has hitherto been left largely to private enterprise. Once more, however, our national genius for doing the illogical thing has succeeded beyond any reasonable expectation, and we have to thank the Gas Industry for financing *Enough to Eat* (1936), an examination into the problem of malnutrition among the working classes in this country, *Housing Problems* (1937), slum life described by those who live there, *Children at School* (1937), a review of British public education, contrasting new schools with those on the 'black list', and *The Londoners* (1939), describing the activities of the L.C.C. More recently the Oil Industry has followed suit with *Speed the Plough* and *Roads of Britain*. In America *The Plough that broke the Plains* and *The River* have been produced for the United States Resettlement Administration and the United States Department of Agriculture respectively.

The effectiveness of the film as a means of propaganda is well demonstrated by the success of the American 'March of Time' films. The instantaneous popularity of this series astonished even those who conceived the idea, for the cinema trade as a whole was

pessimistic; it knew far better what the public wanted. Nevertheless, the series is regularly shown in 1,300 theatres in this country and in over 10,000 theatres throughout the world. Although the ideal behind these films is to present, as objectively as possible, accounts of world happenings, there is no doubt whatever that they are helping to mould our views on such happenings. In America legislation regulating child labour, which has repeatedly been rejected by a majority of States as unwarrantable interference, has at last passed both Houses of Congress by a narrow margin which is believed to be due to the 'March of Time'. Their film on cancer has done a good deal to arouse the national conscience of America to the evils of the quackery that battens on fear of this scourge, while in England, before the present campaign for National Fitness was under way, their film *Food and Physical Training* aroused enormous interest and debate in that it brought home to many people's minds the fact that the animals at the Zoo are better fed and housed than many of the nation's children.

One must include in any survey of the film used for civic purposes the recent run of American crime films deliberately designed to give glory to the preservers of law and order instead of, as had previously tended to be the case, to lawbreakers.

The sporadic and spontaneous nature of British effort in this direction makes a curious contrast with the purposive film-propaganda of Russia, Germany, and Italy. It is to be predicted that only in the event of war, and perhaps not even then, would such a preponderance of state-sponsored material be likely to appear on the screens of this country.

Nevertheless, we may anticipate that the government departments, no less than twelve of which now employ public relations officers, will make constantly increasing use of the film in order to create and maintain contact between the public and the public services. The main problem involved in such an activity would be that of putting the films produced into circulation. Here,

however, the example of the G.P.O. may be quoted to show the possibilities of well-organized distribution through travelling units and sub-standard libraries. It is calculated that during the year 1938 G.P.O. films reached an audience of two and a half million people. Further possibilities for the diffusion of films of this nature may soon be offered by television.

Television

The cinema industry as a whole is primarily concerned in purveying entertainment using photographic film as a vehicle. It is now clear, however, that television will soon provide an alternative method of distributing moving-pictures, a prospect which some film distributors view with resentment, some with alarm, and some with optimism.

The latter, perhaps in the long run likely to prove the most far-sighted, are already interesting themselves financially in the development of television to a point where electrical projection will rival that of the photographic film in its quality. Whatever befalls, they intend to have a foot in both camps. Those who resent the intrusion of television are somewhat illogical, for the cinema was itself responsible for practically killing the variety stage and it has expressed no compunction at forcing the theatre into second place. Moreover, as H. G. Wells's Mr. Smallways was fond of remarking, 'This here progress keeps on keeping on', and whether the cinema industry likes the idea or not, television is eventually going to exert a profound influence on it, perhaps even to alter it radically. At the present stage of development, prophecy is likely to prove wide of the mark, but conceivable lines of progress suggest that the alarm which is sometimes expressed is not entirely justified.

The contention that a televized film service will empty the cinemas is based on the assumption that when people can see a televized programme at home for 10*s*. a year they will be disinclined to leave the fireside and pay money to see substantially the same programme

at a theatre. On the other hand, if the public's contribution to radio and television is limited to 10*s*. per set per year it is doubtful whether programmes of a quality attainable by the cinema industry would be financially practicable. Indeed, the sums demanded by the sponsors of big topical events would probably be as much as television, financed out of licence revenue, could provide.

Then again, man is a gregarious animal and his emotional responses are enhanced by crowd enthusiasm. Moreover, he is interested in change and, since he must spend a good deal of his leisure hours at home, he welcomes the opportunity of entertainment elsewhere. He is just as likely to abandon his present habit of driving about in motor-cars from one place to another largely for the sake of the motion, as he is to abandon his visits to the picture theatre for home television.

Even assuming that, for some years to come, television remains unpractical as a theatre entertainment, it now seems certain that, by the time there are sufficient privately owned televiewers to make an appreciable difference to the box-office receipts of a televized film, the average release film will be in really first-class natural colour. The theatres will have the pull here since televized natural colour, when it comes, will almost certainly be beyond the pockets of the bulk of the population, for it must not be forgotten that nearly 90 per cent. of a modern cinema-audience pays not more than 7*d*. for its seats, and these are the people who are financing the cinema industry.

A far more likely outcome is that, by the time an appreciable fraction of the population possesses televiewers, the cinemas themselves will be equipped for projecting both topical events and films by television, and that such rivalry as exists between the television and the cinema industries will be no more important than that existing between radio and the gramophone, between the radio news bulletins and the newspaper.

Arguing from analogy with the gramophone, which was almost immediately adopted as a home entertain-

ment, many people thought that the cinema would also come into the home. The cinema, however, grew up on the basis of theatre exhibition because commercial success was dependent on quality, quantity, and cost of production. Television will possess an equally voracious appetite for entertainment matter, and it is likely to prove an ally rather than a deadly rival of the cinema industry.

Nevertheless, the fusion of television and the cinema would probably result in far more radical changes than those which followed the introduction of the sound-film. In the production studio, for example, the scenes in a feature film may eventually be recorded via a televized image, and the photographic quality of the film image will be predetermined far more precisely than is practical at the moment. Rehearsals will be viewed by the director watching a screen image rather than the scene itself, film need not be wasted in recording them, and the effect the producer wants will become less a matter of trial-and-error shooting. The images themselves will be recorded in a laboratory rather than on the studio floor, the pictures being under continuous observation during the recording, and exposure being adjustable at will by variable amplification of the incoming signals. Not only will the scope of the resulting picture be increased, but a reduction in production costs may quite easily follow the adoption of television as an ally in the studio.

Cinema theatres equipped with television projectors may receive the entertainment they project by land lines from centralized distributing stations, and a greater variety will become possible in the programmes. One can also visualize a rapid growth in the importance of the news theatre. However, it is time that we descended from the clouds—or rather the ether—and took leave of our readers, for our subject is the cinema to-day, and our review is completed. Whatever lines of development are adopted, one thing is certain: the motion-picture industry will in course of time grow up. It may lose some of its charm in the process, but it will shed

a great deal of that crudity which at present stands between it and the critical appreciation which it deserves. One may expect that the first symptom of its maturity will be a curbing of those ebullient outbursts of self-congratulation which at present pass in the film world for good publicity. The average advertisement of the average film to-day is a piece of hysterical nonsense which even a masterpiece would find it difficult to live down. While this state of affairs persists we can hardly blame those who regard the film as the *enfant terrible* of the Arts.

The bulk of films to-day may be made by people who can only think through their glands and are primarily engaged in drawing the soothing blankets of illusion over the bitter truths of existence, providing a dope that too often prevents rather than stimulates thought. Nevertheless, it is beginning to be realized by the enormous potential audience who rarely go to the cinema for the same reason that they rarely read novelettes, that the most important purpose of education in our time is the training of the mind to deal intelligently with the individual issues which face mankind; and that in the discovery of cinematography we have, in addition to a source of entertainment, a potential civilizing influence that may ultimately be of greater importance than the discovery of printing.

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